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COMPARISON OF MILITARY AND COMMERCIAL DESIGN-TO-COST AIRCRAFT PROCUREMENT AND OPERATIONAL SUPPORT PRACTICES

BOEING AEROSPACE COMPANY
SEATTLE, WASHINGTON

JULY 1975

TECHNICAL REPORT AFFDL-TR-75-64
REPORT FOR PERIOD JUNE 1974 – JULY 1975

TvE

Prepared for
AIR FORCE FLIGHT DYNAMICS LABORATORY
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio 45433

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This technical report has been reviewed and is approved.

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This technical report compares military versus commercial design-to-cost procurement and operational support practices on selected aircraft derivatives such as the 707/E-3A AWACS, 737/T-43A Navigation Trainer and 747/E-4A Command Post. Comparisons, where applicable, are made for six major program phases beginning with initial planning and ending with operations and support. Recommendations are included where the military can benefit by incorporation of cost-effective commercial practices.

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PREFACE

This report was prepared by the Boeing Aerospace Company, Research and Engineering Division, Seattle, Washington, under USAF Contract F33615-74-C-3100. The contract was initiated under Project 12070137, Identification of Aircraft System and Program Improvements Leading to Support Cost Reduction. The work was administered under the direction of the Air Force Systems Command (AFFDL/PTC) with Nathan L. Sternberger as Project Engineer.

Boeing Aerospace Company's principal investigators were Mr. R. E. Reel and Mr. D. L. Quigley. The contractor's report number is D180-18703-1.

This document includes work performed from 3 June 1974 through 3 July 1975. Document is submitted 3 July 1975.

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SUMMARY

The experience of aerospace companies who are engaged in both the military and commercial aircraft business suggests that comparison of the commercial approach to design-to-cost management of an aircraft program with that employed by the Department of Defense will yield many proven cost saving/cost reduction techniques and practices which can be directly applied to military weapon system procurements. To achieve this objective, the study is directed at determining those aspects of commercial aircraft procurement and operational support, which if applied to the DoD environment, will result in significant reductions in the unit fly-away and life cycle support costs of future USAF aircraft.

This study assembles and analyzes existing data generated principally on derivative military aircraft programs. The derivative military/commercial programs contributing to the study are the 707/E-3A AWACS, 737/T-43 Navigation Trainer, and the 747/E-4A Command Post. Data is also presented from the YC-14, B-52 and helicopter programs.

The principal findings and recommendations of the study, which appear to be cost-effective for implementation by the government, are listed below. Complete recommendations are included in Section VI.

Immediate Benefit

Finding 1:
The application of the current airline maintenance practice for wide-body aircraft, as identified by MSG-2, is saving the airlines approximately 40% in manhours over the then-current practices. This technique for determining the essential scheduled maintenance requirements for new commercial aircraft is practical and effective on derivative aircraft. The initial estimates on the B-52 and E-3A programs are savings of 25% of the manhours expended for scheduled maintenance. The practice is being incorporated in MIL-M-5096D. Besides the savings in manpower, aircraft availability also increases. (Section III.F.)

Recommendation 1:
Expand the use of this commercial maintenance concept (represented by MSG-2) to all aircraft programs. Initiate its use on Aerospace Ground Equipment (AGE) and Transportation equipment.

Finding 2:
Many airline operators have no scheduled engine maintenance, other than replacement of life-limited parts, because of the reliability of the engines as evidenced by operational data. On the T-43A program where the commercial engine practices are followed due to its derivative status and contractor logistics support, there will be 76 fewer scheduled engine changes. Besides saving an estimated 7.5 million dollars in hot section inspection and overhaul costs, many Air Force maintenance manhours and much fuel for runups and flight tests are saved. Aircraft availability is increased. (Section III.F.)

Recommendation 2:

Adopt this commercial jet engine maintenance practice to all derivative programs which utilize commercial versions of jet engines. Investigate its use on military aircraft programs where military versions of commercial jet engines are used in similar types of flying, e.g., B-52, C-141, C-5A, and C/KC-135. Adopt this practice on other jet engines where reliability has been proven by experience data.

Finding 3:

The airlines utilize an engine derating practice by reducing takeoff thrust on occasions where conditions of temperature and runway length permit (approximately 50% of the time). The procedure has been approved for the T-43A program. Airline savings have been noted in decreased fuel (5%), hot section reliability (up 3-fold), inflight shutdowns (down 89%), premature removal rate (down 50%), engine maintenance material (down 20%), and engine overhaul labor (down 2%). (Section III.F.)

Recommendation 3:

Adopt engine derating practices on all military aircraft by reducing takeoff thrust when conditions of temperature and runway length permit.

Finding 4:

The use of contractor support on existing fully operational derivative programs (C-9A and T-43A) is saving the government up to 40%-45% in logistics costs. Contractor experience in base custodial maintenance contracts shows contractor labor is less expensive than government labor. (Section III.F.)

Recommendation 4:

Expand the use of contractor support to all derivative programs and to other on-base support functions such as transportation squadrons. Study the application of contractor support to purely military aircraft or military aircraft with commercial derivatives (C-130).

Finding 5:

The implementation of certain government procedures increases the cost of derivative programs. Through the first ten months of 1974, AFR 55-22, "Contractor's Flight Operations," increased the cost of then-current derivative programs approximately $600,000. Other requirements, whose applications increased contractor costs of operation but were not quantifiable from the data analyzed, include AFM 127-101, AFSCR/AFLCR 66-24, T.O. 00-25-172, and MIL-STD-483. (Section III.E.)

Recommendation 5:

Delete the requirement for application of AFR 55-22 and similar documents for which existing contractor documentation has proven to be adequate.

Near Term

Finding 1:

The conversion of commercial data, equipment and hardware to military specifications or standards increases the cost of derivative aircraft. The difference between the cost of maintenance handbooks was almost triple on the T-43A program. Equipment and hardware costs increase 5%-10% due to low quantity, 50%-100% for reliability testing and up to 15% for special requirements such as finishes, special testing and verification requirements, standards and sealants. (Section III.F.)

Recommendation 1:

Utilize existing commercial data, equipment and hardware in off-the-shelf form. When not available off-the-shelf, use commercial specifications. Add military requirements only on selected unique equipment and/or where the commercial data is inadequate to satisfy system requirements.

Finding 2:

The application of military practices on derivative programs often duplicates commercial practices which are already covering the intent of the military requirements. Few "how-to" specifications, such as "MIL-S-6872, Soldering Process," are required by experienced major military contractors on aircraft programs. Others, such as MIL-F-8785, "Flying Qualities of Piloted Airplanes," are not required unless there is major modification to the configuration, or the use of the derivative is a wide departure from normal commercial use. (Section III.C.)

Recommendation 2:

Limit (or delete, as appropriate) the application of military specifications on derivative aircraft programs.

Finding 3:

The use of the aircraft as a training platform is expensive. Airlines have reduced the ground training by 25%, the simulator time up to 15% and the actual flying training by 50% by the use of modern audio/visual devices, new type procedure trainers and modern simulators as well as the use of the "Specific Behavior Objectives (SBO)" approach. (Section III.F.)

Recommendation 3:

Implement the SBO approach in flight training and expand the current use of greater training by simulators in lieu of airborne flight training.

Finding 4:

Paperwork on military derivative programs may exceed that of commercial aircraft programs by up to 10 times, depending on the engineering discipline. This corresponds to the number of customer personnel interfacing on each program. (Section III.C.)

Recommendation 4:

Vest military aircraft program control in a relatively small number of highly skilled and experienced personnel. During the review of the Request-for-Proposal (RFP) prior to its issue reduce all data requirements to the "need-to-know" type. Then reduce the data submittal volume. Match data delivery timing with task completion schedule to reduce the number of revisions.

Finding 5:

The overall military flight test program requires almost 50% more flight time than the equivalent commercial flight test, training and route proving program. Most of the differences relates to functional and reliability testing. (Section III.E.)

Recommendation 5:

Review Categories I, II and III flight test requirements on derivative programs relative to existing commercial and Federal Aviation Administration (FAA) test procedures. Use existing contractor procedures or form new simplified integrated test and evaluation procedures as required.

Long Term

Finding 1:

Many military specifications and standards overlap each other and make it difficult for the designer to know that he has complied with the requirements. There is the added complication in that specifications reference specifications that reference other specifications. On the derivative programs reviewed, there are 18 military specifications, standards, etc., on electromagnetic interference (EMI) versus nine for the commercial aircraft. One military standard supersedes two military specifications, yet all three are included on E-3A and E-4A programs. (Section III.C.)

Recommendation 1:

Consolidate existing military specifications, standards, regulations, manuals, and special documents.

Finding 2:

Commercial customers rely heavily on past performance in the decision of purchases. Contractors and vendors with good performance history are considered more favorably and with fewer restrictions than those who are new to the design and manufacturer of an aircraft type, part or equipment. Specifications are written accordingly. (Section III.D.)

Recommendation 2:

Structure each RFP on the basis of the previous experience of the major contractors being considered. An alternate would be to include past performance in the proposal evaluation rating system.

Finding 3:

Refinement in the design and price on commercial programs are continued from the time of preliminary design completion until the decision to go ahead is made. In contrast, refinement on military programs without prototypes essentially ceases with the submittal of the RFP (equivalent to the end of the preliminary design stage). (Section III.A.)

Recommendation 3:

Request contractor review of each RFP prior to its release and pay him for the work unless the recommendations are held in confidence and considered a part of his response.

Finding 4:

The review and coordination of proposed changes to the contract, design, specification or other elements of a program take up to four times as long on a military program as on a commercial program. Commercial customers establish decision-making personnel at the contractor's facility to make all but major decisions and these are often made by telephone. (Section III.B.)

Recommendation 4:

Improve the change flowtime by (1) locating some key System Program Office (SPO) personnel with the contractor and with authority to make decisions within a designated area, or (2) delegate more decision responsibilities to the Air Force Plant Representatives' Office (AFPRO).

Finding 5:

The commercial practices shared by the airlines, contractors and the FAA offer economical application to military aircraft programs, particularly for non-combat aircraft.

Federal Air Regulations (FARs) generally stipulate the end results required, leaving the approach and demonstration of attainment up to the manufacturer. The FAA witnesses and approves the demonstration. Military specifications are generally much more detailed, often describing exact techniques which are mandatory, with in-process inspection by DoD personnel required to demonstrate compliance.

The FAA delegates selected technical tasks to certified contractor personnel with a corresponding reduction in cost and flowtime for both the contractor and the government.

Two categories of designated representatives are used in the development of new aircraft:

- Designated Engineering Representative (DER) - A DER is authorized to approve engineering information and data within the limits of his designated field specialty whenever he determines that the information and data comply with the applicable regulations.

- Designated Manufacturing Inspection Representative (DMIR) - A DMIR is authorized to approve quality assurance matters similar to the DER in engineering.

(Section III.B.)

Recommendation 5:

Implement derivative (or possibly new military aircraft) program management and administrative requirements by beginning with the contractor's specifications and FARs (limiting the application and flowdown of additional requirements to areas of genuine need) and utilizing the FAA DER/DMIR type system on a military program.

Finding 6:

The acquisition phase of a commercial program is much less stringent in area of details required and customer/contracts communications. This allows an evaluation of the proposed system through the concept/proposal phase to production authorization, thereby optimizing the cost versus performance of the system. The rigidity of the military process does not allow much evaluation because of the restriction on communication and the requirement for sustaining a status-quo competitive condition. A contractor, thinking he has a competitive advantage, might very well decide not to include significant innovations/deviations in his proposal because of the probability that these improvements would be imposed on all other proposals, including those already disqualified. This results in several possible disadvantages: (1) should the leading technical proposer submit his improvements and they, in turn, get imposed on all other contractors, the winning contractor could be the least technically qualified and win on cost alone, (2) should the contractor with the improvement lose the competition, the improvement may never be realized by the program, (3) should the winning contractor elect to propose his improvement after winning, the cost of the improvement would increase because of program interruptions, delays and loss of the competitive environment.

Recommendation 6:

Revise the mechanics of the military acquisition process to permit better communication/interface between the customer and the contractor without jeopardizing the contractor's proposal. There should also be provisions which allow a contractor to submit improvements without losing his technical advantage.

The complete set of recommendations is contained in Section VI. Further discussion is found in Section III. The feasibility of implementation is discussed in Section IV. Cost impact of the above, where data is available, is found in Section V.

SECTION I

INTRODUCTION

The experience of aerospace companies, engaged in both the military and commercial aircraft business, has indicated that a comparison of military and commercial design-to-cost aircraft procurement and operational support practices may show cost reduction differences in techniques and practices which are directly applicable to military weapon system procurements. This is especially true of commercial derivatives for military programs which in themselves are a major step in the direction of adoption of commercial practice. This study, therefore, covers the analysis and comparative evaluation of selected military and commercial program pairs such as the 707/E-3A AWACS, 737/T-43A Navigation Trainer, and 747/E-4A Command Post. It also reviews cost patterns, where applicable, of the YC-14, B-52 and helicopter programs during all phases of system life cycle. The study is limited to areas wherein comparison is meaningful, i.e., mission equipment on the E-3A has no commercial equivalent so it is not considered.

The basic objectives of the study are to:

- Identify differences between military and commercial aircraft design-to-cost procurement and support practices.
- Evaluate significant differences relative to magnitude, cause and impact on life cycle phases and costs and on total program costs.
- Determine practicability of applying selected commercial practices to future military aircraft program acquisition practices to achieve cost reductions.

The technical approach for accomplishing the study is shown in flow diagram Figure 1.

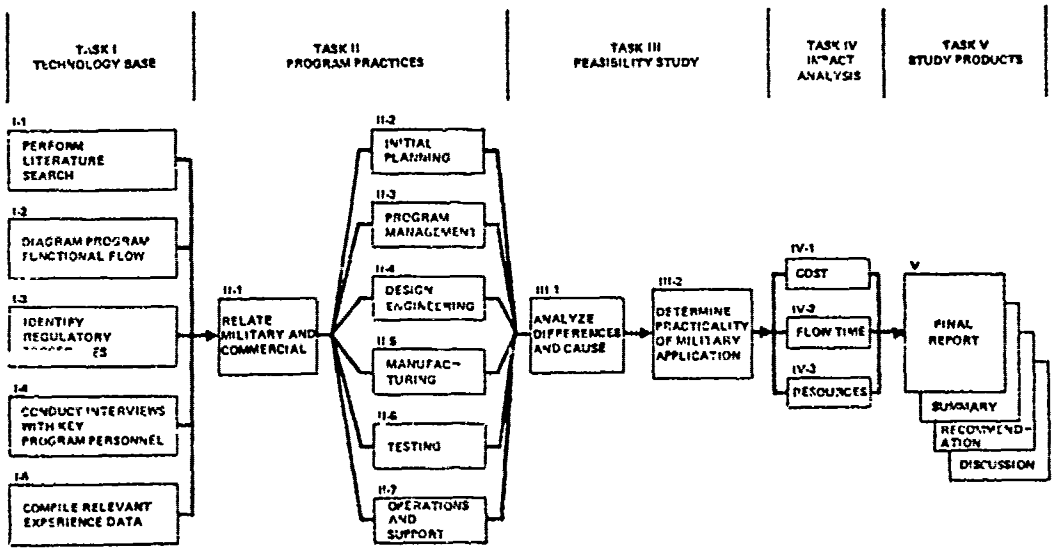

Figure 1. Approach

The five main tasks are described below:

Task I: Technology Data Base

Develop a military and commercial data base required to conduct the study and needed to identify and analyze those acquisition and support practices used by commercial businesses which would help reduce the costs of military aircraft programs. (See Section II.)

Task II: Analysis and Comparison of Military and Commercial Practices

Using the technology data base compiled as required by Task I, examine, analyze, identify and compare the acquisition and support practices of the selected military and commercial programs and relate these practices in each program studied to the various management phases including planning, design, development, test and evaluation, manufacturing/production, and operations and support. (See Section III.)

Task III: Feasibility Evaluation Study

Analyze the extent of the differences identified in Task II to determine the cause and program impact of each difference within each of the phases detailed in that task. Using the information developed, evaluate the feasibility and practicality of modifying present military acquisition and support practices and procedures and of adopting existing or some modified variation of unique commercial practices to defense procurement and operational support. (See Section IV.)

Task IV: Impact Analysis

Analyze and compare the differences in military and commercial acquisition and support practices in terms of cost, flow time and resources required and evaluate the impact of the commercial practices identified for application to military programs in those same terms.

In Section V the contractor presents the cost impact of imposition of military practice on an otherwise "all" commercial aircraft. Data from an earlier 747 Command Post study tends to "scope" and "bound" the inverse case of an "all" military aircraft shift to commercial practice. This Command Post study is supported by other available data in terms of cost, flowtime and resources.

Task V: Study Products

The analyses and evaluations derived from this study are used as a basis for developing the recommendations (See Summary and Section VI) regarding the feasibility and practicality of modifying military procurement and support practices and procedures which contribute materially to high acquisition and operational costs and/or applying high payoff commercial practices to military programs to achieve reduced costs.

Most of the products of this study were presented earlier in interim oral status reports.

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SECTION II

TECHNOLOGY BASE

The initial literature search for this study includes utilizing data found in program data files, libraries, and the files of the Experience Analysis Centers on military programs, cost studies and related information, and on commercial programs and studies. An informal search continued throughout the study and additional data was provided by individuals contracted during the course of the study. The list of these data are contained in Appendix A, Parts 1.0 and 2.0. Identification of significant regulatory controls imposed on military and commercial acquisition programs is made from reviewing the AFSC Design Handbooks, a military aircraft specification (KC-135), a commercial aircraft specification and the specification trees for the E-3A, E-4A and T-43A derivative programs. Appendix A contains a portion of this data in Parts 3.0 and 4.0. (For example, the E-3A contract and specification includes 244 first tier government specifications, standards and similar technical documents, not including specifications for mission equipment.)

To correlate the individual specifications, a comparative listing is made of the military specifications and their commercial equivalents. This list is presented in Appendix B.

Supplementing the literature search, additional information was obtained through questionnaires and interviews. Two questionnaires were used to pinpoint areas of concern and to determine the major differences in these areas of concern. The first questionnaire used multiple choice answers to a set of questions tailored to contractor practices. These were sent to a number of key personnel experienced with both military and commercial programs, including program managers, design engineers, test engineers, materials and process engineers, cost analysts, buyers, manufacturing planners, quality control inspectors and logistics engineers. The Program Management questionnaire with composite answers, shown in Figure 2, is typical. Each questionnaire provides for additional items as well as other suggestions to acquire information.

The compilation of the answers is shown in Table 1. (The summary of questionnaire answers by discipline is contained in Appendix C.) Greater involvement of more people, due to, or resulting from more specifications and data requirements, is pinpointed on nearly every return as a major difference between military and commercial programs.

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Program Management

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	Degree of preliminary planning	9*	5	3	1
2.	Number of trade studies	2	5	4	2
	2a. Configuration	4	6	5	4
	2b. Cost	5	5	5	3
	2c. Customer	6	1	5	5
	2d. Competition	4	1	8	2
	2e. Subcontractor	4	8	4	
3.	No. of controls	10	4	3	
4.	Size of team	9	5	1	2
5.	Freedom for long-range planning	2	1	2	13
6.	Customer coordination	9	3	2	4
7.	Vendor/Assoc./Sub. involvement	4	7	6	1
8.	Industry involvement		9	5	3
9.	Directives (Command Media)	8	6	3	1
10.	Use of current state of technology		5	7	5
11.	Upper management review	3	7	5	3
12.	Time required for decision making process.	11	7		
13.	Written correspondence	15	2	1	
14.	Phone conversations	10	8	2	
15.	No. of file cabinets for records	8	6	4	1
16.	Establishment of Program Goals	3	7	6	2
17.	Establishment of Design-to-Cost Goals	4	3	8	3
18.	Marketing involvement		2	2	13
19.	Facilities requirements	4	7	5	2
20.					
21.					
22.					

23. OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information:

*Sum of all answers received. Not all responders answered all questions.

Figure 2. Typical initial Questionnaire

TABLE 1. INITIAL QUESTIONNAIRE SUMMARY

Phase	Questionnaires	Line Entry Answers - Percent Comparison - Military to Commercial			
		Much More	More	Same	Less
Initial Planning* Program Mgmt*	54	33	33	24	10
Design Engineering	44	33	34	30	3
Manufacturing	17	17	49	28	6
Testing	11	30	49	18	3
Operations and Support	11	24	39	16	21
TOTAL	143	31	36	26	6

*Includes Program Management, Contract Administration, Finance and Preliminary Design

Based on analyses of the answers to the initial questionnaire, a second questionnaire, which focused on the identified areas of concern, was sent to selected personnel including many managers at all levels. Where any of the answers indicated, an interview followed. Interviews were also conducted with personnel at other contractor locations by telephone. The answers and interview information are included in this report. Copies of the second questionnaire are included as Appendix D. Each set of questions has two parts - one part which is general in nature and applies to all phases and a second part which relates specifically to the discipline of the addressee. A set of the second questionnaires was forwarded to the Air Force Study Manager for Air Force use.

One requirement of this task of establishing a technology base is the investigation of the functions within each major program phase. Analysis of both military and commercial typical program phases indicates that at the level of the major phases, shown in Figure 3, it is possible to make a comparison because the major phases are similar. The military phases shown are those presented and described in AFSCP 800-3. The typical commercial program phase activities are described as follows:

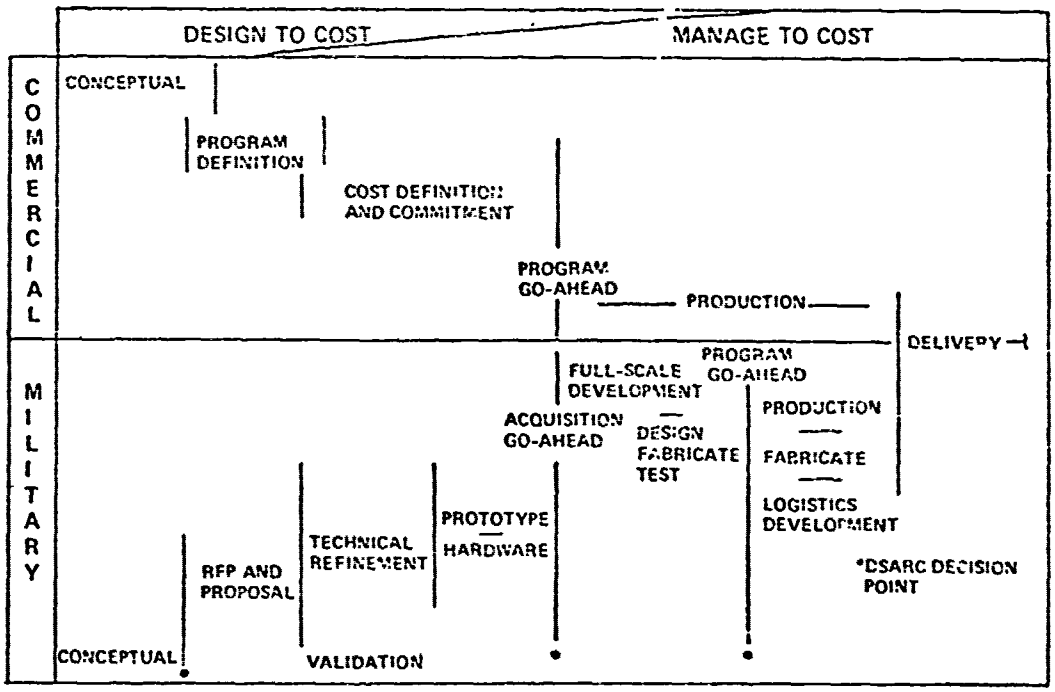


Figure 3. Phases of a Typical Program

1. Conceptual Phase: For analysis of the market, definition of the market segment to be covered, definition of candidate design concepts, verification of technical program feasibility, establishment of potential profitability, investment requirements and limitations, airline contacts and definition of the type of program participation.

2. Program Definition Phase: For market research and analysis of requirements, establishment of airplane performance objectives to meet market requirements, establishment of airplane configuration, analysis and documentation of technology, establishment of nominal performance and guarantee objectives, documentation of configuration (Design Data Document), establishment of program planning and management principles, establishment of work allocation principles and firm work allocation plan, establishment of programming for baseline program, establishment of initial work package definitions and preliminary cost estimates and allocations, establishment of profit and pricing objectives, establishment of business and financial risks, identification of resources required and preliminary cash-flow analysis and identification of key management and related assignment plan.

3. Cost Definition and Commitment Phase: For firm configuration definition, complete technical validation, customer specification development, establishment of definitive implementation plans and internal commitments signed by key managers with production phase responsibility, completion of firm commitment agreements on major vendor items, establishment of price and other basic sales terms and conditions, verification of resources required including capital assets, verifications of program cost and cash-flow and profitability risks, submittal of sales offers, negotiation of firm sales contracts, establishment of the production plans, and obtaining corporate approval for program go-ahead.

4. Production Phase: For marketing and sales, cost and price verification, airplane detail design and development, design verification testing and airplane certification, manufacturing and assembly, production deliveries, and post-delivery customer support.

The timing of the elements prior to "Program Go-Ahead" depends upon the individual program and can vary considerably although the calendar time from program go-ahead to roll-out of the first aircraft is essentially the same on both military and commercial programs according to available data. The commercial programs place the preliminary design activity closer to the "go-ahead" date, since once this effort is complete and detail design begins, little of the management leverage of design-to-cost effort is left; i.e., the basic design (fixed wing versus swing wing, three engines versus four engines, pressure vessel, etc.) is fixed with only the details of sub-system components left. The military overcomes some of the disadvantage of an early RFP (less opportunity for continued iterative design review and improvement and dialogue between buyer and seller) by use of the prototype fly-off concept.

SECTION III

PROGRAM PRACTICES

Task II of the study utilizes data from Task I to identify significant differences between military and commercial procurement environments and acquisition and support practices in the various phases of initial planning, program management, design engineering, manufacturing, testing, and operations and support. These are discussed in the following paragraphs. This report does not discuss the many excellent practices of military programs or the commercial practices which do not appear to be advantageous or applicable to military programs.

A. INITIAL PLANNING

Initial Planning is defined as that activity in the acquisition of a program which precedes the decision to begin production of the end product and its support systems. The conceptual and validation phases are the phases of a typical military program which are covered by this activity. Comparisons of military and commercial programs include identifying differences in the initial planning approach/philosophy, sequence of events, marketability, and customer requirements such as objective and need. A majority of the responses to the initial questionnaire shows that significant differences between military programs and commercial programs are in the areas of preliminary planning, controls, people, customer coordination, directives, decision cycle, communications, facilities, documentation, specifications, meetings, visits, and preliminary design. There is little difference in the freedom for long range planning, market investigation, wind tunnel use, computer use, completeness of design and internal coordination.

1. Customer Philosophy/Objectives

In comparing the acquisition and operational use of military and commercial aircraft systems, certain basic differences in philosophy are apparent. Military weapon systems tend to have a more complex set of requirements to fit a new or specialized mission, with emphasis placed on performance, operational and maintenance effectiveness, and initial investment cost. (Lowest initial investment appeared to be the major determinant for the selection of the contractor in those programs analyzed in this study.) Commercial aircraft design tends to progress by evolution with heavy reliance on past experience. The normal requirement is to perform an existing mission more economically. Commercial operators tend to be more willing to consider trading performance for improved reliability, lower operating cost and decreased development risk. (Competitive pressure may also result in greater performance.) Military systems are procured for contingency use and normally introduced into a peacetime environment. This generally results in a longer test program and a lower initial fleet introduction rate than is normal for airline application. As a rule, commercial operators are interested in the delivery of their aircraft, particularly the first ones, at the earliest possible date to maintain a competitive edge and improve the profitability of their operations. This results in high initial production rates (to support all customers), expedited test programs, and rapid accumulation of flight time, field experience, and performance data.

Figure 4 illustrates the product design philosophy used on commercial programs to optimize the economic value of the product. The cross-hatched band on this chart indicates the estimated range of potential value to the customer of the various design criteria of the product. There are two important points in this curve; first, that the market value of a product or a feature of a product is not a finite quantity; it can only be estimated within a range. Secondly, that as the design is improved on a particular characteristic of a product, there is a tendency for each increment of improvement to have diminishing additional value to the customer. In the crosshatched band is shown the range of probable cost to the manufacturer of producing a product that meets the specified performance characteristics. Again, there is not a finite estimate, but rather a range. Further, it is important to recognize that as the performance parameters are pushed to higher and higher levels, the cost begins to rise quite dramatically. The overlap area of the cost range and the market value range is viewed as a design window into which the product must be fitted. Through the center of this design window is drawn what conceptually might be called the practical limit of the commercial state of the art. Beyond that point, it is apparent that the cost of the product has a high probability of exceeding the market value. Most commercial programs will be somewhat less than the limit (Area 1). In contrast, most military programs are in the right-hand area of the design window (Area 2). However, the new Air Force procurement emphasis

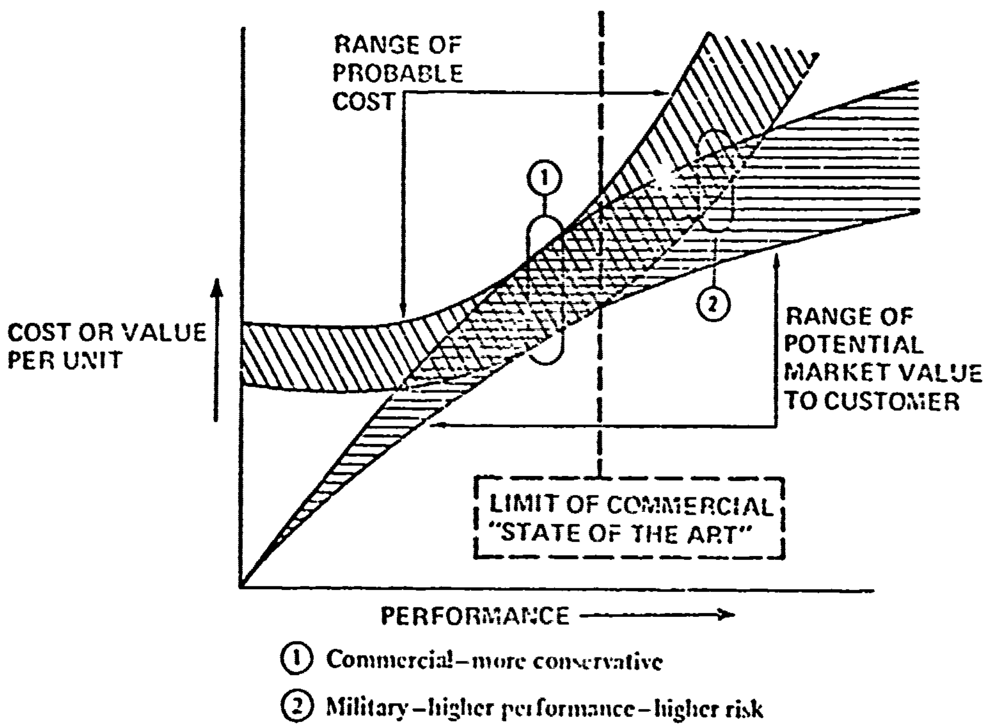


Figure 4. Product Design Philosopny

is attainment of satisfactory mission performance for the lowest life cycle cost expenditure, as discussed in paragraph 2. One of the major applications of the design-to-cost practice would be to determine how much closer the military programs can realistically move toward the commercial state of the art in order to achieve the cost levels and the cost confidence that are desired to be achieved, still maintaining defense posture.

The nature of a commercial customer is one of a profitmaking business. Of necessity, success motivation is high since company success and career opportunities are directly related to profitable procurement decisions. Accordingly, the authority to commit to expenditures and procure commercial airplanes or changes to the basic design, is tightly controlled within the customer's organization. If the pilots of a particular airline want the cockpit redesigned to their preferences, there must have been justification based on cost and the benefit in real business terms (safety, efficiency of operation, etc.). If the maintenance people want interchangeability of all nacelles, there, also, a justification must be established based on cost savings in the future. Each cost added must be justified in terms of return on investment (ROI).

Figure 5 illustrates the economic investment, recovery and profit for a major commercial aircraft program. On a commercial program the focus of management decisions is on the total program and its ultimate return

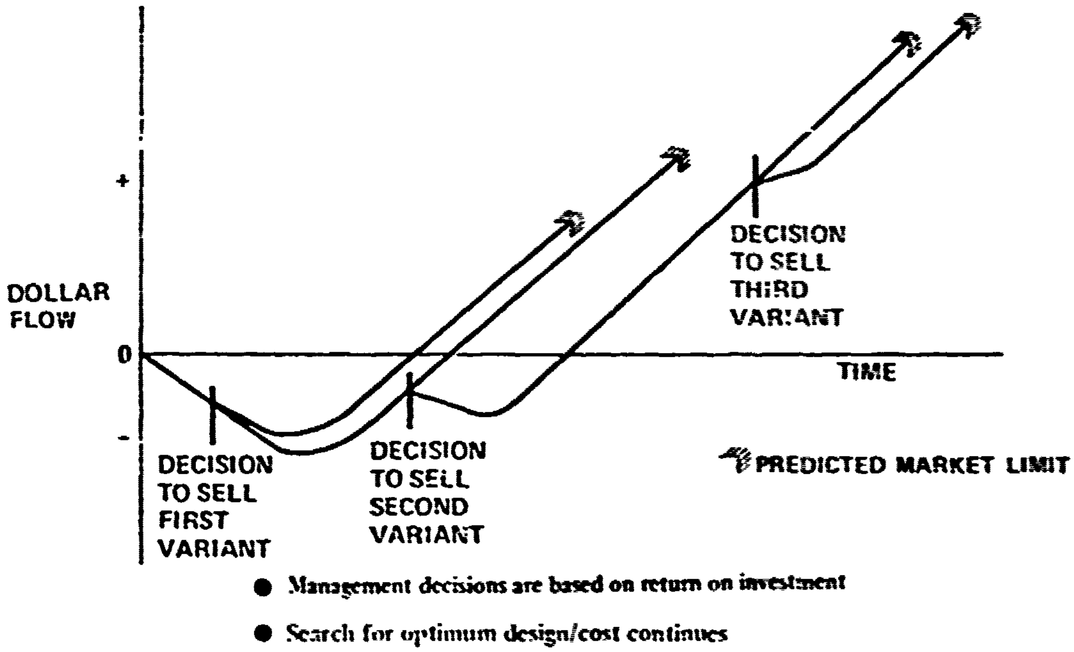


Figure 5. Program - Investment, Recovery, Profit

on investment rather than on one procurement phase or fiscal period at a time. Also, the search for a more optimum design and lower cost continues throughout the program. This effort may be considered as a "re-investment" since additional funding is normally required. The military parallel for re-investment is believed to lie in the engineering change proposal (ECP) effort of the military customer and the contractor to achieve the optimum design and the optimum cost of the total program. This effort may be limited to the immediate fiscal period. Thus, what commercial managers consider "re-investment" in the total program sense might be considered as a "cost overrun" by some reviewers of a military program.

2. Design-To-Cost Approach

In the past, the typical military request for proposal for an end item specified minimum performance requirements and specific schedule requirements. A proposal which did not meet the performance or the schedule requirements was generally judged not responsive and therefore out of the competition. The cost varied, depending on the design approach to fulfill the stated requirements. Normally the lowest cost bid won, irrespective of the design approach submitted.

Current military directives state that cost must be included in program trade-offs. The design-to-cost approach states that with respect to overall program goals, cost will be an equal factor with performance and schedule in selection of a final design. (Figure 6.)

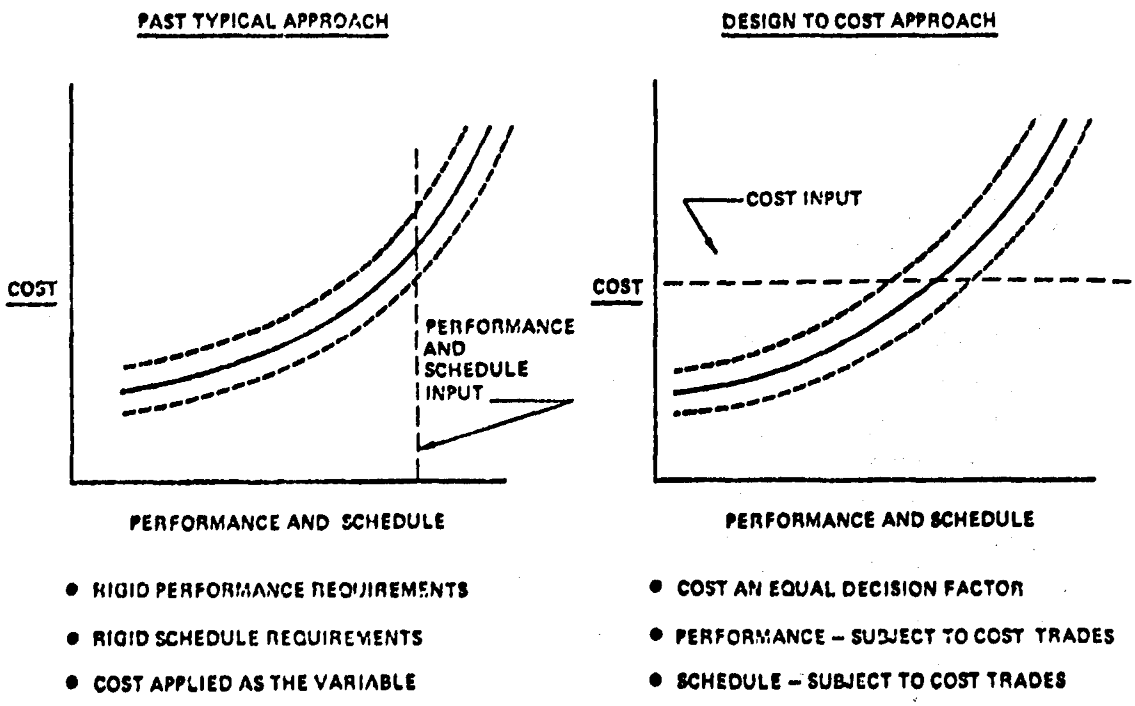
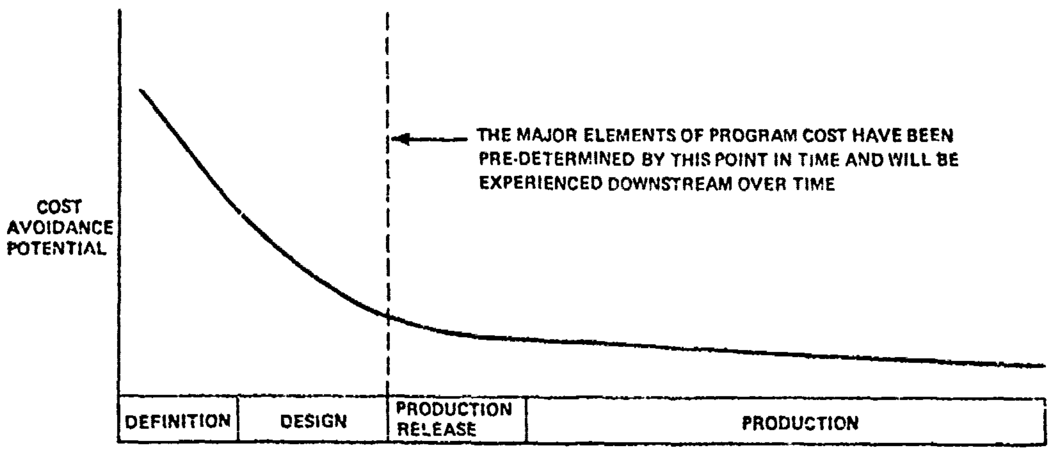


Figure 6. Program Approach

Because of the nature of the commercial industry and the direct connection between profit and loss, cost has always been a trade item in the planning, design, manufacture and operation of the end item. Thus, the objectives are much clearer, perhaps due to the practice of reducing most decisions to cost (or some function of cost) and profit to the manufacturer and the operator. For both of these areas, well established yardsticks are available.

Much of the emphasis on design-to-cost is placed on the design of the product, including its operational and maintenance requirements. However, there are many other program elements that are equally critical, i.e., manufacturing plan, resources (people, facilities, financing), organization structure, management plan, make/buy plan, procurement plan, program schedule, sales/marketing plan and product field support plan.

The important item in program cost is to recognize the fact that the greater potential for cost avoidance is at the beginning of a program prior to design release (Figure 7). The importance of timely use



- THE GREATEST POTENTIAL FOR COST AVOIDANCE EXISTS DURING CONTRACT DEFINITION AND DESIGN WHEN CHANGES HAVE NO PHYSICAL IMPACT

- THE TRUE ESSENCE OF DESIGN TO A COST IS THE THOROUGH DISCIPLINED MANAGEMENT OF A PROGRAM IN THE CONCEPT DEFINITION AND DESIGN PHASES

Figure 7. Design-To-Cost

of available management and design tools during the program development process is emphasized in Figure 8. This figure identifies two phases in a program life; one which might be referred to as the "design-to-cost" phase on the left, overlapping somewhat with a phase which might be called "manage to cost objective." The solid line represents the percentage of costs that remain uncommitted or undetermined at each stage of program. By the end of preliminary design, for example, decisions have been made which commit approximately 70% of the ultimate unit cost and only 30% of the cost is available for management leverage. Cost leverage is the ability to further reduce the cost. By the time the program is into production and is approaching delivery, the manufacturer has an influence of perhaps 10% on the ultimate acquisition cost of the program. This is true, even though only 30%-35% of the funds will actually be expended by that point as shown in the dotted line.

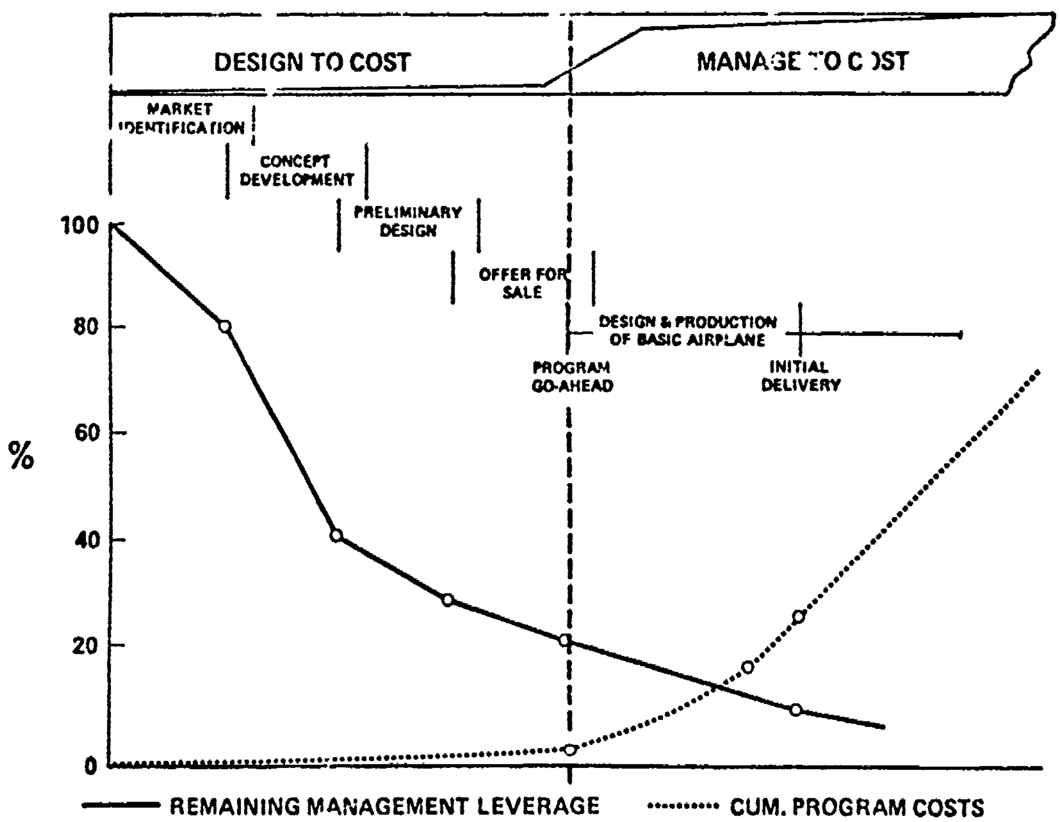


Figure 8. Phases of a Typical Commercial Program

3. Program Acquisition Practices

A review of the different practices used in the acquisition of military and commercial products indicates that similar steps are taken on both programs. The structure of the commercial program and the contractor/customer interface, however, is much less detailed and rigid than that of the military. The contractor is continuously in contact with the commercial customer during each step to determine his needs and desires, thus obtaining the visibility needed for refining and improving overall product performance. A direct comparison of customer actions in the different approaches used in each type of program during acquisition are presented in Table 2.

TABLE 2. PROGRAM ACQUISITION

MILITARY	COMMERCIAL
• determines and internally coordinates the requirement • solicits proposal • selects contractor	• determines requirement or is presented proposal • interacts with contractors to improve it • selects contractor
• internal evaluation with little or no knowledge by contractor	• relatively continuous interface from concept to go-ahead
• multiple bids solicited or proof of necessity of sole source	• selects contractor based on part reputation, product, cost, and/or timely availability of the product
• can always challenge cost through higher court	• no challenge available if product meets requirements
• specs say what, how and require much data	• specs say what but require little data
• little if any warranty (at least in past procurements)	• significant warranty
• long term funding very vulnerable depending on social-political-economical environment	• long term funding available depending on market and management skill
• current or past performance can have relatively little impact on follow-on business depending on product	• contractor past performance on meeting guarantees and in product support has major impact of future business
• decision based on cost • performance or schedule exceeding RFP requirement of little value	• decision based on cost and best ROI as determined by best performance, schedule and lowest O&S costs

The military customer normally makes his decision on the proposed cost, based on proposal performance and schedule. Often the RFP response must be made within an extremely short time. It is here, to a major extent, where life-cycle costs are determined since preliminary design must be fairly complete if the contractor is to have a credible proposal. The commercial customer and the contractor continue to iterate the design until a contract is signed. The military customer selection process may take longer and require the contractor to remain in a holding position without opportunity to improve his design offering. On the other hand, the commercial contractor continues to improve his design or increase his confidence with the customer, thus improving his bargaining position. The contractor normally works with the military customer from the time the need for a military product is identified, through the conceptual phase, and into the validation phase up to the time of writing the RFP. The writing and review of the RFP is accomplished without formal contractor assistance, yet many detailed features of the design, schedule, and program administration (and correspondingly, cost) are determined by the RFP. Hence the contractor may have to respond to some less-than necessary "requirements."

Some government agencies are now advertising for RFP review prior to its release. This will enhance the environment for "tailoring" of requirements and specifications to the specific program, and, perhaps eventually, tailored to take advantage of a specific contractor's unique expertise.

An example of the difference between commercial and military RFPs and responses is shown in Table 3. The contractor received an RFP in typical

TABLE 3. PROPOSAL EFFORT - CAM

(Preliminary design study sub-contract)

Initial (typically commercial)	–	**3 page–RFP** **44 page–proposal**
Final (redirected by gov't)	–	**600 page–RFP** **446 page–proposal**
Increased cost of proposal effort	–	**$80,000**
Increased study cost for spec compliance	–	**28.5%**

commercial format (three pages) from the prime contractor of a government program to perform a preliminary design study utilizing a commercial aircraft. The RFP was subsequently reissued in accordance with prime contract requirements because the cost exceeded the procurement threshold. The estimated increased cost due to specification compliance was 28.5% on a four million dollar contract in the example shown.

The major problem in the validation and source selection phase facing the military and the contractor is to improve the visibility of the most important matters and reduce data volume and resource application on those items which are well understood. Without this tailoring the data packages which are prepared to support a military procurement tend to be large. (Note the example above.) Since the commercial customer is only the user and has the FAA to participate relative to airworthiness, his requirements for data are few. But the FAA also has fewer data requirements. (The small quantity of customer data is offset somewhat by the many commercial customers.) The military customer requires data to provide visibility that each phase of every element has been met to his satisfaction. Cost avoidance will occur if fewer data requirements are appended, especially to relatively low risk, proven items; e.g.,

- to request data readouts on the KC-135 inflight refueling boom when it was installed on the 747 and operated by Air Force boom operators
- to demonstrate the T-43 could be recovered and prepared for takeoff at home base in a maximum of 45 minutes elapsed time when the 737 had been doing better than that for over five years
- to verify the flying qualities of derivative aircraft
- to require reliability analytical verification data on the purchase of off-the-shelf equipment which has been in commercial use for a number of years, and
- to require material accountability on equipment in satisfactory performance on commercial aircraft programs.

One of the basic objectives of the government for the Validation Phase is attainment of an accurate prediction of production costs and a commitment by the competing contractors. As a practical matter, this objective is somewhat difficult to achieve at an early stage. Because of the emphasis on price competition and government contracting rules (he must submit and commit to plans or be non-responsive), much of the data, planning and performance commitment may not include adequate consideration of unknown technical problems.

When technical problems do arise, as the program proceeds, it becomes necessary to modify the original planning. It is important that an environment be sustained wherein programs are able to flexibly adapt programming to resolve emerging problems.

B. PROGRAM MANAGEMENT

Program management, in this study, encompasses the functions involved in the management operation of an organization. It includes decision-making, planning, scheduling, cost control, reporting and selection and use of resources and affects all organizations in all other phases of a program. This task identifies the differences in the program management process applied to past military and commercial programs, considering such items as defined goals, iterative planning, decision-making processes, cost control, and size and continuity of the management team.

Analyses of the answers to the initial questionnaire indicate th. . 'he basic difference between military and commercial programs is the involvement of more people when interfacing with the military customer. This results mainly from larger numbers of specifications, standards and regulations and the detailed documentation and coordination resulting therefrom.

1. Management Procedures

Identification of some fundamental management differe' .s between development of a commercial product and a military pr. . ict is presented in the following paragraphs. These differences also explain how comparable functions are performed on contractor commercial programs and when the techniques of DoD management procedures are applied.

A relatively "structured" system engineering discipline is used on military programs to determine equipment and other requirements based upon necessary functions to be performed by the system. This discipline is especially applicable when system functions are new and their technical solutions are either complex or have significant technical risks.

With commercial aircraft programs, however, a different approach is followed. Aircraft have a substantial heritage of proven solutions to many varying requirements. Essentially, all aircraft have a common series of "functions" performed inflight. The major task facing an aircraft designer is to apply the latest proven technical developments to improve the performance of each of those functions. Example: The use of functionally oriented logic to discover that the aircraft needs a wing is, of course, not necessary. The major task facing the aircraft designer is how to improve the wing efficiency. Even such requirements as wing area, wing loads and control surface areas are fairly exacting decisions, each determined analytically after weighing reasonable alternatives.

This difference can also be viewed in another manner. The commercial customer is not separately funding research and development (R&D) but, instead, is buying an assembly line product with specific performance guarantees. Consequently, these significant differences emerge:

(1) In the procurement and funding of R&D,.the government tends to retain review and approval authority on technical decisions, design approaches and the justification of selected solutions from alternatives. To exercise this authority, extensive documentation of supporting data is required. Time is required for bringing each receiver of data to a knowledgeable decision level. Extensive data is often required to satisfy the needs of government agencies.

(2) In the commercial market place, the contractor deals with a relatively few engineering representatives of each customer, whose concerns are similar but not as detailed as in the military practice. The commercial concern for achievement of specified performance is expressed through contract provisions for warranty. (Warranty for military programs is being studied but no contractor position has yet been established.) Under these conditions, the manufacturer is able to decrease the paperwork involved in the justification and recording process and to rely more upon proven judgment of the persons to whom program responsibility is entrusted. Furthermore, the FAA (which has interests similar to those of the Air Force) delegates much of its airplane certification review authority to the contractor. This step expedites actions and minimizes assigned government personnel and documented justifications.

The practice, used by the FAA to decrease the decision cycle time as well as reduce data flow, utilizes contractor employees as Designated Engineering Representatives (DER) and Designated Manufacturing Inspection Representatives (DMIR). A contractor employee, skilled in specific disciplines (in engineering, this would be hydraulics, electrical, avionics, structures, etc.) is designated as a representative for the FAA. He is authorized to certify that certain specific designs and tests comply with Federal Air Regulations and submitted test plans. The FAA engineers retain jurisdiction to concur with his decisions and also to determine what other designs and tests can be accomplished analytically or operationally. To limit the number of operational tests, the commercial contractor utilizes the DER's knowledge to assure that the original design and design changes comply with the FAR criteria and thus be assured that FAA will certify the product. If, in the performance of this duty, there is disagreement between his decision and that of the company management, the matter is referred to the FAA for final decision. The same is true with DMIRs and the Quality Assurance Department. The DER/DMIR practice works well commercially. This practice and its implications should be studied for implementation feasibility on a new Air Force program.

The data submitted by the DER to the FAA are usually one page reports as are other data submitted to the FAA to present plans, analyses, and administrative data. Simplicity is the key. Conversely, in military practice, the form complexity and amount of documentation required is greater.

Several questionnaire responses indicate data and documentation requirements in excess of what is needed may cause a problem, especially if the program element providing the data has not stabilized and the data is requested too soon.

The contractor has solved the data problem to a great degree with its suppliers on commercial programs by use of a Supplier Data Requirements List (SDRL) (Figure 9). This is a one page matrix of data requirements patterned after the military CDRL and is included with each order to the supplier. The persons needing data complete the appropriate blanks prior to the order being placed. The supplier, by referring to the basic purchase agreements, then knows what and how much data is needed when and prices it accordingly. A similar form is currently being applied to derivative programs for the non-commercial equipment required from suppliers.

2. Cost Control and Management

DoD Instruction 7000.2, Cost/Schedules Control System Criteria, is a subject of much discussion. Although finance managers generally accept the principles of this document for cost control, across-the-board application of this instruction can result in additional data which requires more people. Questionnaire data indicated that cost estimators on military or military derivative programs must be increased threefold over similar commercial programs to perform the added work load. Although the computer helps offset some of the added costs, additional manpower is required because the application of the DoDI requires a level of detail below that on which the original cost data is based. A ripple effect throughout the program is then felt. This DoDI also sometimes causes monitoring of individual parts or non-deliverable sub-systems; for example, the hydraulic sub-system on one derivative program.

Participating finance managers indicated other areas of cost that can result from military programs.

a. Accounting Systems - Accounting systems have to be designed to accommodate billing and cost collection systems associated with cost type contracts for the military. In general, these systems require more detail in the data than would be required for similar commercial programs.

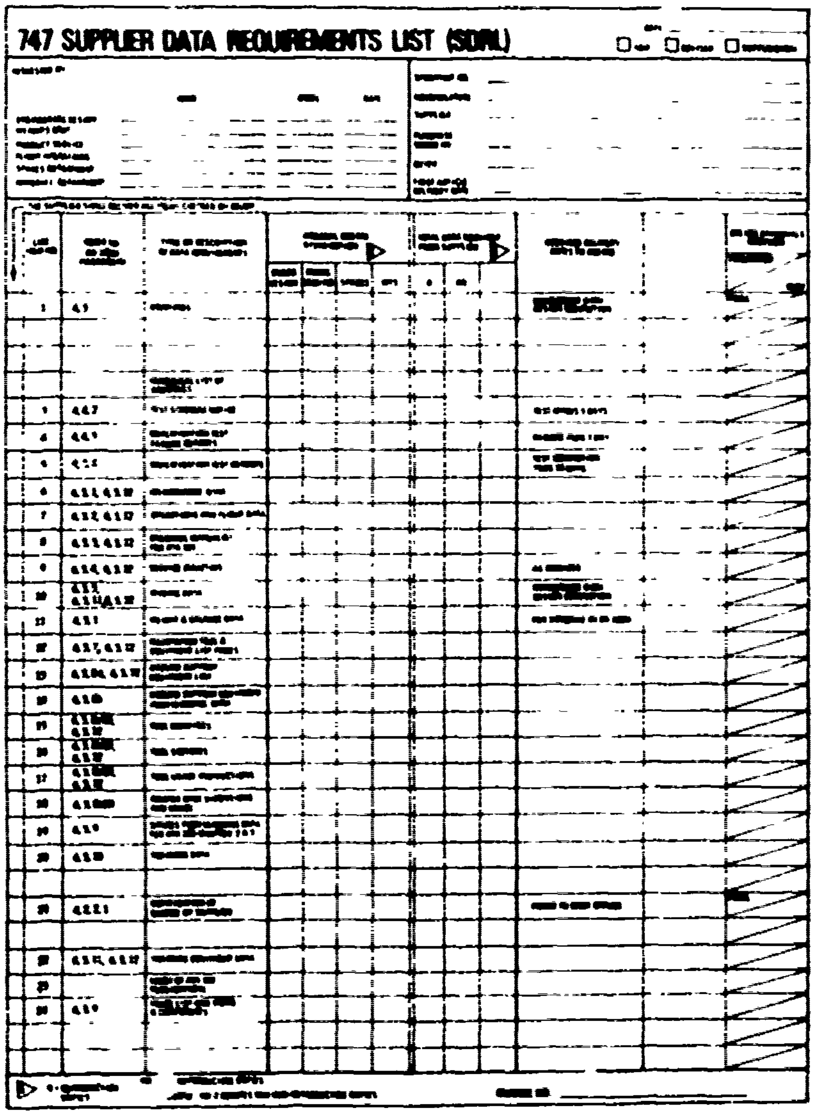

747 SUPPLIER DATA REQUIREMENTS LIST (SDRL)

Figure 9. 747 Supplier Data Requirements Lists (SDRL)

b. Accounting Rules - The need for interpretation of the various accounting rules as set forth by ASPR and the Cost Accounting Standard can result in periodic allocation of resource to resolve questions on the allowability of costs.

c. Billings - At times the contractor has to invoice down to small work packages and provide cost justification at this lower level. It sometimes happens that funding availability does not properly match contract effort in terms of "color and hue" of money. This results in added effort between the contractor and the government procurement office.

d. Overhead - The overhead settlement is required for each year for all cost type contracts and is done by evaluating the contractor's overhead costs for past years. It requires a continuing effort to validate costs that may have been incurred in previous years.

e. Functional Audits - Audits are performed to determine the contractor's adherence to the latest interpretation of the accounting and procurement practices. Support of these audits requires added effort.

f. Negotiation of Prices - It is sometimes difficult to forecast accurately all costs that will be incurred, particulary in high technology contracts. It is sometimes difficult in negotiations to reach agreement on resource allocation for unknowns.

g. Disclosure Statements - All contractors that have military business above a certain doller amount are required to have on file a Disclosure Statement which defines the cost collection systems to be used. Since the systems require governmental approval, any changes, for whatever reasons, are subject to review by the government thus requiring added effort.

These areas are recognized as part of the cost of doing business with the government. The major contractors accept them. (The small contractors/businesses are refusing to accept government business because of them.) As an example of d., above, the last contract for the KC-135 aircraft is not yet closed although the last delivery was over ten years ago.

3. Configuration Control

Configuration management techniques, as identified in the standards, are generally applicable to both commercial and military aircraft programs. Configuration identification and control techniques have largely evolved from less formal techniques in general use for years. While the contractor commercial activities do not specify the MIL-STD. per se, the configuration controls provide essentially the same capability. Figure 10 shows the commonality. The commercial programs are not as extensively documented as the government requires. When tailoring is not done carefully on a military derivative program prior to contract signing, the government and the contractor expend additional coordination effort on proposed waivers and deviations when requirements are not compatible.

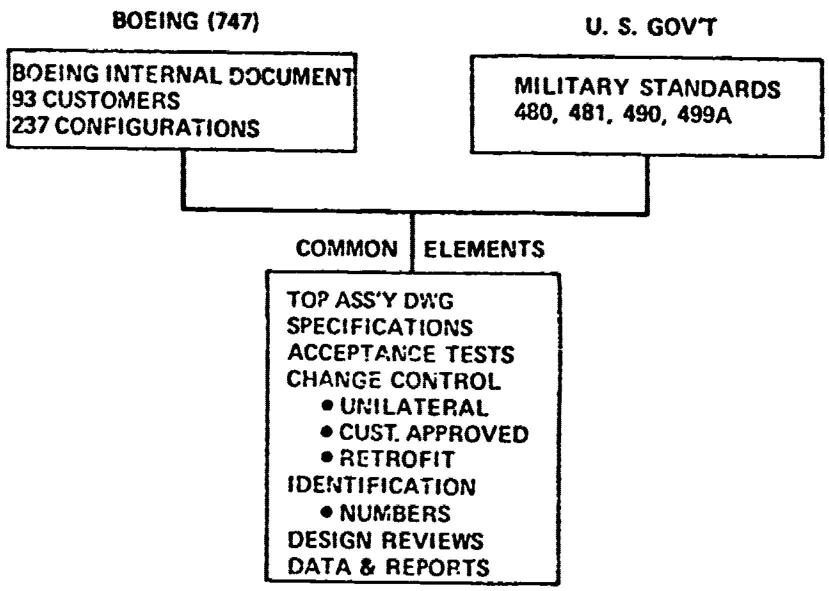


Figure 10. Configuration Management and Control Concept

4. Customer/Contractor Interface

The task of handling the relatively large number of commercial customers is quite complex.

During the time period of pre-delivery after sales, the following major segments of the commercial company are coordinating inputs and replys from the customer.

1. Sales
2. Contract Administration
3. Engineering
4. Manufacturing
5. Customer Support

Each one of these major groups is broken down into smaller operating groups that handle particular facets of any specific requirement.

Currently the commercial company is simultaneously handling the individual inputs from over 100 airline customers, operating a fleet of over 2,000 aircraft made up of four basic models.

While delivery of the aircraft reduces the involvement of some departments within a group and increases others, each customer still has access to and requires support from each of the groups.

Though the same channels of communication remain open after delivery, another communication line is introduced. Unlike the military which is a single operator under a single command, each airline is a unique operational entity and as such will have its own individual problems. The commercial program has more than 70 bases around the world all feeding problems into the home base. These issues are handled within the company and then corrective action is fed back to the customer. The commercial customer support organization supports these 70 plus field bases and more than 100 customers with a vast communications network. A description of the assistance provided to the commercial customer is presented at the end of Section III-F.

C. DESIGN ENGINEERING

Design Engineering includes those activities of design and product assurance accomplished during the detail design of an aircraft. The study task effort identifies major differences in military and commercial acquisition practices as they relate to design engineering. Consideration is given to sensitivity of performance versus cost, design reviews and trade-offs, standardization (form and fit), number of drawings, detail of specifications, subcontracting and warranty policies, low cost configurations, and procedures for design changes.

Over two thirds of the responses to the initial questionnaire indicate significant differences in the design engineering phase of military aircraft programs due to more specifications and documents, longer decision cycles, more formal design reviews, more people, greater coordination, more trade studies, more meetings, more trips, and more writing time. The responses also show little difference in the number and quality of drawings, mockups, new vendor items, liaison changes, computer use, design time, new innovations (as distinct from higher technology), research, and experience data.

1. Design Practices

The amount of design effort performed on either military or commercial aircraft programs is essentially the same for equivalent requirements. Figure 11 shows how the relative engineering manhours per part has increased over the years on military and commercial aircraft, primarily, because of increased product sophistication and improved capability. The difference between the two is probably caused by the military customer's practice of operating in the regime of advancing the state of the art (higher risk areas) and to increased data requirements. While the actual

data on which this is based is proprietary, eight different jet aircraft programs over a span of 25 years are included. Estimates run as much as two to three times more for the communication (documents, meetings, travel and telephone) segment of engineering labor. The additional effort does not significantly improve the performances of the end products in the opinion of most persons interviewed.

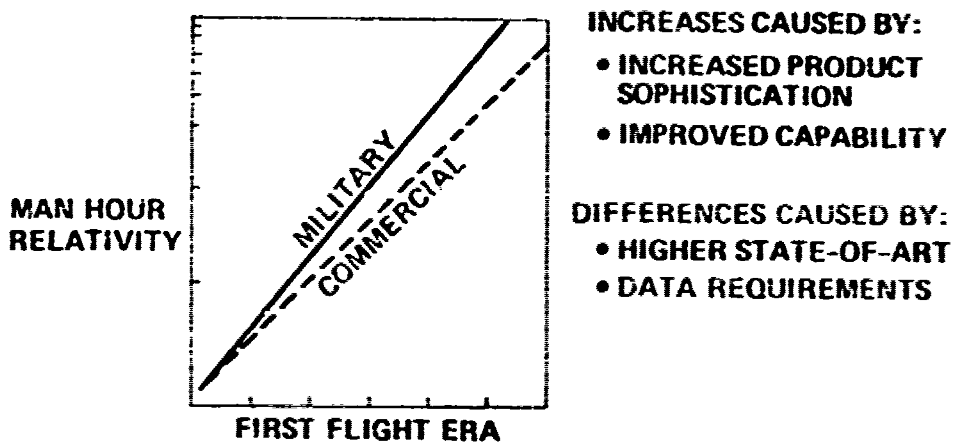
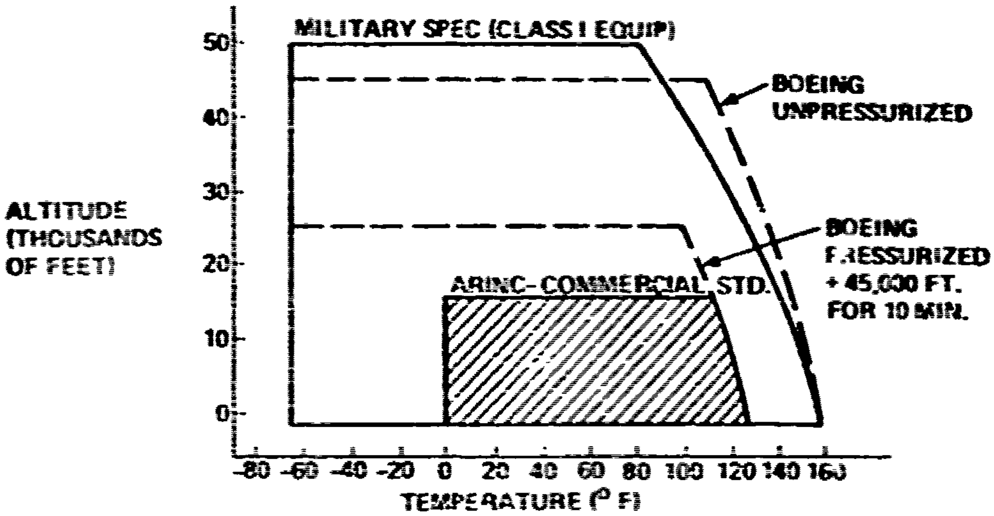


Figure 11. Engineering Labor Per Aircraft Part

Basic differences between military programs and commercial programs are in design criteria. Government criteria tend to be "input" and "control" oriented by military specifications and standards, while the commercial criteria are "output" and "test" oriented by Federal Air Regulations (FARs). The military approach is to specify performance for an aircraft and then include "how to" requirements to build the aircraft to obtain that performance. The commercial approach is to specify the performance and allow the contractor to determine the design which gets that performance. This approach permits much more flexibility in the design and in the control of engineering effort. Figures 12 and 13 show this flexibility for electronic equipment design. The main difference is that military requirements are aimed for their worst known case and multiple use while the contractor commercial requirements are aimed at margin over anticipated use and take advantage of other data based on location of equipment. ARINC is more basic and to some extent may not consider other factors such as margin over average experience, exact location, vibration, dust, corrosion and EMP. Suitable constraints are applied by the FARs and subsequent testing. The commercial customer's reliance upon a performance warranty appears to be much greater than the government's.



Worst case vs margin over average experience

- Pressurized
- Unpressurized
- Aircraft location
- Operator environment

Figure 12. Vibration Requirement Comparison Electronic Equipment

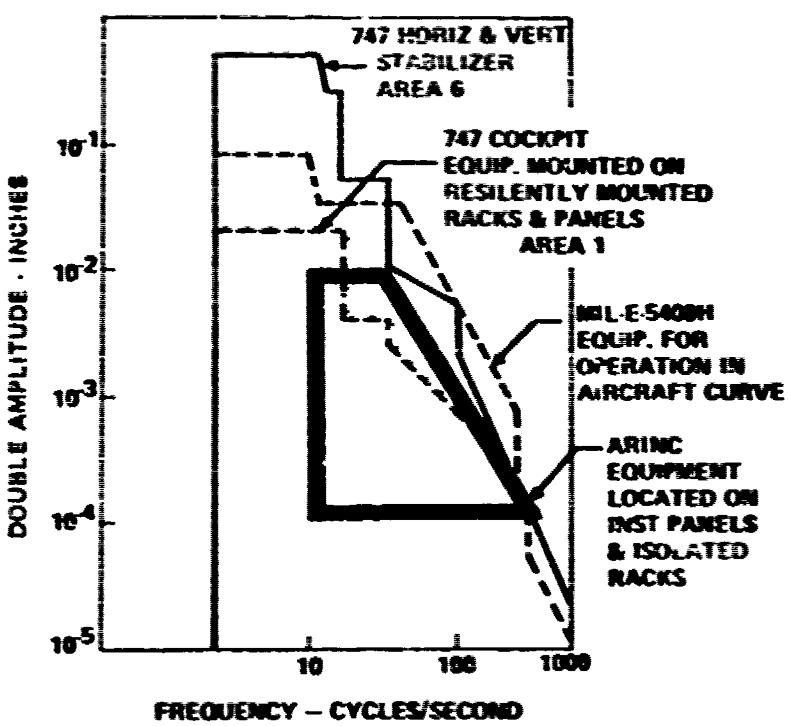


Figure 13. Component Environment Test - Electronics

Military specifications often reference military specifications which reference still other military specifications, until it is difficult (and time consuming) to arrive at a position where a designer is confident that he has met the requirement. There are times where the requirements are too stringent for the application, and it is costly to either meet the specification or get a deviation. (At the present time the normal practice is to expect the contractor to request a deviation of all, or a part, of any specification included in the statement of work (SOW) or contract. This is time consuming and expensive not only to the contractor but also to the government. The SPO has to review each proposing contractor's list of deviation requests to reconcile the proposal so that an equivalent SOW is presented on a common basis to each competing contractor. The government could save money by including in the SOW or contract only that portion or paragraph, by number, of each specification for which compliance is required.)

To further illustrate the differences in government/commercial procurements, the following compressed sequential description of the contractor design process on a commercial program should be helpful. In arriving at a particular commercial aircraft product configuration, the contractor employs mathematical models representing the commercial market and the operational characteristics of individual airlines. These models are configured in a manner to allow optimization of the product (aircraft) with respect to the economic considerations of the airlines. Accordingly, the contractor applies a high degree of cost effectiveness analyses in the early stages of the commercial aircraft system engineering, and conducts extensive trade studies to arrive at the appropriate technical solutions to meet the individual mission requirements of each airline. From these analyses and trade-offs, model specifications and performance requirements for basic missions are developed. The Federal Aviation Agency has published and maintains a rather extensive compilation of regulations with which commercial aircrafts must comply in order to receive certification. (These are listed in Appendices A and B.) These regulations substitute for the need to identify functions as is necessary in military standards on system engineering management. An internal Design Requirement and Objectives Document and a Design Decision Document are prepared for each basic commercial aircraft to reflect the design objectives for the aircraft and its sub-systems, compatible with the model specification.

These documents, although non-contractual, integrate the contractor's experience and thus serve the same function as military specifications and standards to a large extent. They are the contractor's internal plan to assure a design that meets warranty commitment. The commercial procedure then produces a configuration description, performance type specifications, test procedures for significant sub-systems, and outside procured components of the aircraft. Finally, a full complement of drawings and service manuals is prepared. Much of the training of the air crew, maintenance, ground servicing and engineering personnel is performed by the customer. Minimum data is required from the contractor. Design reviews are conducted in a manner similar to the procedures described in the military standards, but normally are not participated in by the customers.

A study of the differences in design criteria as applied to an existing commercial aircraft was made several years ago. This study investigated the changes that would have to be made if the 747 had to qualify to military design criteria. The impact is significant to the non-recurring cost, depending upon the cost consciousness of the person who adjudicates the military specification application process and the degree of tailoring accomplished. The relative costs are shown in Section IV. This study is contained in Appendix E.

There are other problems encountered with military specifications on derivative programs. For example, 707/727/737 aircraft do not meet all the requirements of MIL-F-8785, Flying Qualities of Piloted Airplanes, despite demonstrated and FAA approved capabilities. The differences are discussed in paragraph F. TESTING. There are also cases where the commercial industry feels that military requirements are too loose; e.g., ARINC 413 follows MIL-STD-704, Electric Power, Aircraft, Characteristics and Utilization of, but specifically states not to follow -704A because it contains less rigid requirements.

On one derivative program, existing commercial parts are used when they are applicable. Otherwise, new parts must conform to the applicable military specifications, standards and regulations of the contract. The electrical load control unit used on a commercial aircraft lacked a required feature. Therefore, a modified part was required for a derivative program. This meant that a new procurement specification had to be written, whereas only a few paragraphs could have been changed to make the existing commercial specification meet the requirement. The difference is shown in Figure 14.

	MILITARY	COMMERCIAL
SPECIFICATION PAGES	119	26
APPLICABLE DOCUMENTS	97	8
DATA ITEM REQUIRED	48	15
COST	$1,500	$950

Figure 14. Design Requirements
Similar Item/Same Vendor

The specification and design change problem is always attendant. Changes due to engineering errors, generally caused by the increased sophistication of every new product, military or commercial, and by the tight schedules, are to be found on both types of programs. Other changes, mostly found on the military programs, are in mission and mission subsystems refinement and improvement. The speed with which deficiencies are normally corrected vary widely. One program staff engineer (an ex-Air Force SPO director) explained it this way, "Commercial aircraft are always at 'war' so they get fixed to perform their mission while military aircraft (in peacetime) get derated, schedules get slid, etc., until an emergency comes along. For instance, a commercial aircraft with a landing gear problem would have been fixed very early in the program if that commercial aircraft program were to be financially successful."

Figure 15 shows the time comparison and the gates through which an engineering change must pass. The time required to implement a routine engineering change is fairly constant within the contractor's organization. The additional time, which elapses before approval is received, is basically determined by the customer. In commercial practice, proposal prices and schedules are good normally for only 30 days from the date of the letter. This short decision cycle works well. The best planning time for USAF approval of an Engineering Change Proposal (ECP) includes 45 days for decision from the day the SPO receives the proposal from the AFPRO. On the E-3A program the change cycle averages over 250 days for routine ECPs.

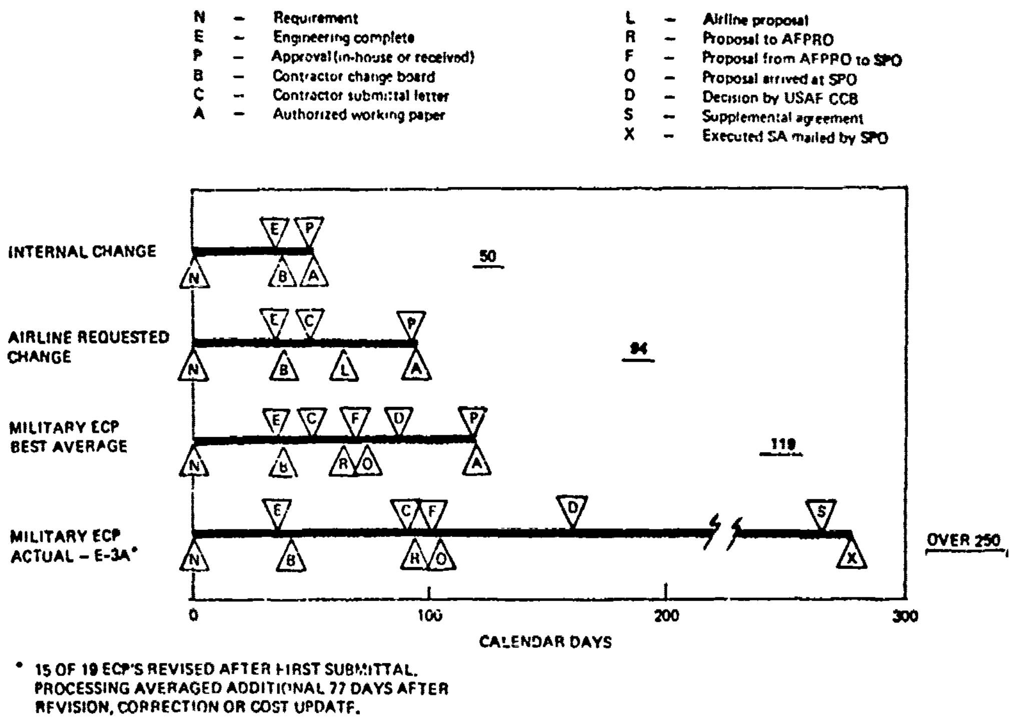


Figure 15. Change Cycle Flowtime (Routine)

The longer decision cycle of the normal military program in times of peace can mean that changes do not get incorporated during production and consequently must be field retrofitted at increased cost. Also, a longer change cycle during RDT&E and production leads to out-of-sequence change incorporation in the factory and during the test program which increases cost.

Engineering managers' comments indicated that, in general, the data required in reporting and coordinating, as well as the time spent on design reviews during a military program, are much greater when compared to a commercial program. Seldom is the end product improved by the submittal of data which substantiates the design, although customer confidence may be. It is not proposed that design reviews should be eliminated but that attendance should be limited to those selected individuals who can effect a meaningful critique of the design relative to requirements. Commercial trend has been to limit design reviews to contractor personnel with the customer present as an observer only (participation might affect warranty).

2. Product Assurance

Product Assurance (PA) is that discipline or collection of disciplines which assures that the end product will fit the operational conditions to which it will be delivered. Maintainability, reliability, safety, and human engineering are basic requirements which must be designed into the product to obtain optimum operational and support cost results. Design-to-cost trades must be applied to support costs equally with other design criteria.

PA requirements should be tailred to fit the program rather than defined separately in the contract and in the various specifications for the individual parts, the sub-system and the end product.

Sometimes separate evaluation and demonstration programs may be required. Ways need be found to achieve similar results by integrating product assurance activities in line with engineering analysis and the test process. The cost of complying with reliability requirements, based on a commercial supplier's interpretation of what was required, is portrayed in Table 4. This part, a high temperature logic (HTL) integrated circuit, was one of seven being purchased for use on the electrical power generation control circuit equipment of the E-3A aircraft. The price for all seven parts in the required quantity would have been $4600 as used on the commercial aircraft. The total price rose to $47,500 by requiring testing per MIL-STD-883 (including both Group B and C tests). (MIL-STD-883 covers testing on circuits as JAN-TX (Hi-Rel) does on equipment.) The contractor and the military customer then reviewed the operational considerations in detail for the requirement of high reliability and the mission essentiality of each part, with subsequent reduction in price to $20,100. While the reliability of these parts to this level is required because of the operational consideration, the example illustrates

that the requirements are subject to varied interpretation and that reliability requirements do cost and must be tailored to the specific end item and the application under consideration.

TABLE 4. COST OF RELIABILITY

DERIVATIVE PROGRAM
PART - HTL INTEGRATED CIRCUIT
NUMBER REQUIRED - 100

REQUIREMENT	MINIMUM QTY	PRICE
● STANDARD COMMERCIAL	100	$ 498
● 100% SCREENED PER MIL-STD-883	100	$1480
● SCREENING PLUS GROUP B TESTING PER -883	1241 (1)	$5925
● SCREENING PLUS GROUP B & C TESTING PER -883	1372 (1)	$8410

(1) 1000 MINIMUM BUY PLUS TEST SAMPLES

The typical Product Assurance program on a commercial program is an integrated effort which results in a maintenance program. The three primary objectives are to (1) minimize the length and number of delays (reliability), (2) reduce maintenance requirements (maintainability), and (3) reduce maintenance costs (maintainability and reliability). The most significant characteristic of a successful PA program is the translation of customer needs into meaningful, practical requirements which can be met by the designer, verified in the product and used effectively by the operator. The description of this PA effort on the 747 is contained in Appendix F.

On military and commercial programs the PA emphasis is on using prior experience with components to avoid known problems, and to use proven components, where possible, for reliability and commonality. On military programs one frequently has many new components and systems as well. However, on any program, only about 20% of all components cause about 80% of all the maintenance costs due to unreliability. The commercial PA effort is to concentrate on this 20% rather than try to cover all items. AFM 66-1 data can pinpoint the major offenders on existing Air Force programs. (The Government-Industry Data Exchange Program (GIDEP) can also provide useful data on problem parts, components and materials.) The same offenders will usually be major problem items on new programs. The chart developed for the YC-14 Program is shown in Figure 16.

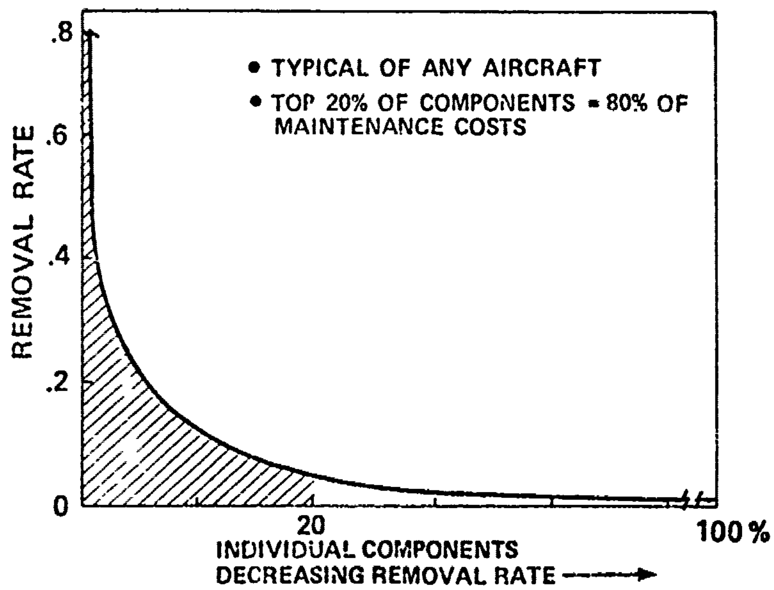


Figure 16. Maintenance Cost Drivers

Effective use is made of existing data in commercial programs. Only that sub-system which is new or only a part of a sub-system which is new is given PA analysis and testing. For example, if a radio system utilizes the same RT unit and same antenna as on a currently produced aircraft but the cabling is new between the two, only the cabling is given PA effort not the entire sub-system. On derivative programs, the initial trend was to follow normal military practice on both existing commercial and new military systems and sub-systems in lieu of using available commercial data and concentrating only on the redesigned, modified, or changed portion. Recently, however, greater emphasis is being placed on using available data, both commercial and military, to reduce costs.

Military programs do have difference requirements (combat ready, more alerts but less flying, lower labor skills) than commercial programs, but the difference is not proportional to the order of the PA cost difference between military and commercial programs. "Tailoring" PA requirements to accommodate proven hardware and existing data will reduce costs in this area.

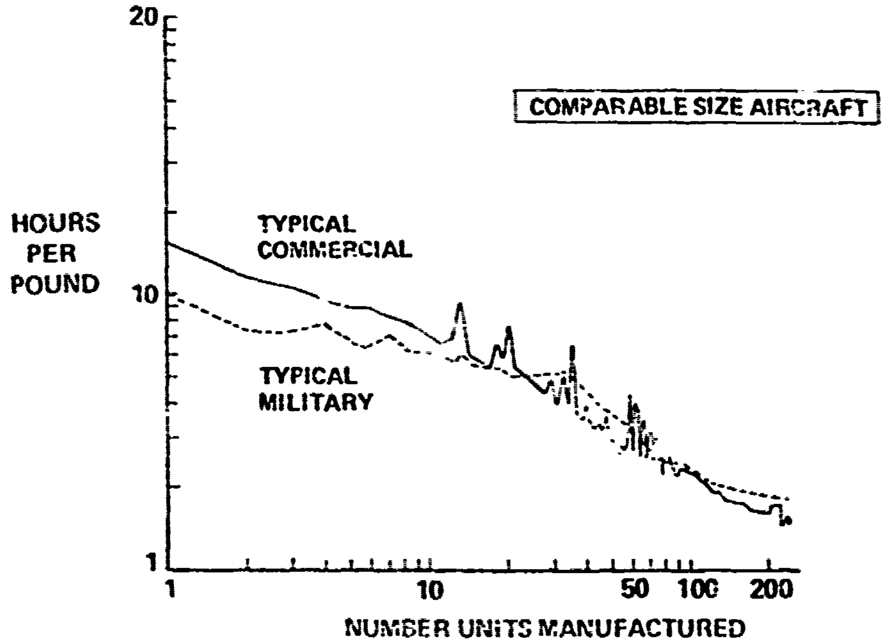
D. MANUFACTURING

Manufacturing includes fabrication and assembly, quality control and purchasing as related to this study. The principal effort of this task consisted of identifying significant differences in military and commercial controls of the manufacturing process. This effort included standardization and commonality, tolerances, materials and process specifications, production rates and schedules, quality control inspections, volume of engineering changes, out-of-sequence modifications and manpower loading.

Analyses of the data gathered, showed that additional technical, purchasing and manufacturing controls result from military programs even with the purchase of an "off-the-shelf" aircraft. Unlike commercial contracts, the government contracts for derivative aircraft affect the contractor's manufacturing operations in that some procedures and systems must be modified and/or new ones created to comply with the requirements. In some instances dual operations may be created (e.g., one inspection line for commercial parts and another for military parts; or one procedure for buying commercial and another for buying military parts for derivative programs - sometimes separate and individual procedures for each derivative program). These costs could be avoided by having all changes to the basic aircraft accomplished to commercial standards as was accomplished on the Peace Station program.

1. Fabrication and Assembly

Initial planning studies and production estimates for a new configuration are usually based on Aircraft Manufacturer's Planning Report (AMPR) weight and past performance. At the contractor's, no special difference is planned for military versus commercial programs. Figure 17 compares direct manufacturing labor costs on typical jet aircraft programs. Size of aircraft did not affect the relative effort between military and commercial programs.



- Comparable manhours and learning curve
- Affected by:

Production rate—weight—changes—no. customers

Figure 17. Manufacturing Direct Labor

In the contractor's experience, manufacturing management (an indirect cost) is more affected by application of military requirements than are the shop personnel. There are more meetings with the customer, more proposal requirements, and more contract status and problem reports when compared to commercial practice. These collectively require more management time and meetings to plan, implement and control the added requirements.

A case in point is the review of AFSC/AFLC Regulation 66-24, "Maintenance of Aerospace Vehicles and Related Support Equipment," which provided the following examples:

1. It was difficult to locate all 34 sub-tier military publications which were required to determine compliance to the regulation.

2. After extensive coordination with AF agencies involved, it appeared that a lack of common understanding of the requirements existed.

3. Recent visibility indicates that the regulation is being rewritten to achieve a better common understanding.

Action taken on the application of this regulation is typical of most and is illustrated in Table 5.

TABLE 5. REGULATIONS CAUSING INCREASED COSTS

AFSCR/AFLCR 66-24, Maintenance of Aircraft

- **Has 34 first-tier publications**
- **Spent several hundred manhours to review**
  - **Parts will be complied with**
  - **Parts will be complied with by intent**
  - **Parts are not cost-effective to comply with**
  - **Parts can be complied with but will be negotiated**
  - **Parts do not apply**

MIL-STD-1518, Fuel Handling

- **Initial estimate of compliance is $500,000 in capital expenditure**

AFSCR/AFLCR 66-24 is an example of a general comment made by several managers during the course of the study: "The military requirements are not always valid. They sometimes try to anticipate every problem ever to be encountered and provide "how to" solutions on new product technology which may not fit very well." The net result is that the contractor may find himself being asked to commit to requirements which may not be cost-effective or necessary for the particular program.

Another example of a requirement which results in an indirect labor increase is MIL-STD-483, Physical Configuration Audit. This standard duplicates local Air Force Quality Assurance (AFQA) verification. The audit involves approximately a one-week review of engineering changes, supporting documentation, drawings, and planning, followed by an inspection on the aircraft which requires one or two days.

The work performed after rollout may also be affected by application of government requirements. AFSCR/AFLCR 66-24 was discussed above. Two others need mentioning. They are:

- AFM 127-101, Industrial Safety Accident Prevention Handbook
- T.O. 00-25-172, Ground Servicing of Aircraft and Positioning of Equipment

On two derivative aircraft programs (E-3A and E-4A), safety precautions above and beyond OSHA and contractor's fire department regulations were added per AFM 127-101 and T.O. 00-25-172. These precautions include no maintenance and no APU operations during fueling, thus eliminating the use of two well established safe commercial practices. Conversely, two other derivative aircraft (T-43A and Peace Station) were handled as commercial aircraft where concurrent maintenance, APU operation and fueling were permitted. The latter indicates that tailoring requirements to program needs can be accomplished and will reduce cost.

2. Quality Control

According to Quality Control managers, the application of military Quality Assurance requirements on derivative programs has caused some changes in the inspection system in the area of procedures, records, and facilities. The Air Force Quality Assurance requirements impact how the contractor manages and controls quality as well as measuring the quality of the product and verifying contract compliance of that product. Some military requirements are less stringent than the contractors' and some are more stringent. Specification QQ-A-367, Aluminum Alloy Forging, represents both. It is less stringent than contractor Material Specifications in the following areas: lot acceptance inspection, grain flow conformance, internal defects detection, and stress corrosion testing. QQ-A-367 is more stringent in requiring shot peening all non-stress corrosion alloys instead of being selective as to application.

A study was made by Quality Assurance of twenty-two military specifications to determine the cost significance if these specifications were made mandatory on derivative aircraft. The study showed a cost increase of $40,000 per year, per specification, if 100% compliance to the military specification requirements in Quality Assurance were to be adhered to. This cost figure was based on the detailed investigation of only one set of specifications (BAC 5719 versus MIL-C-5541, Chemical Conversion Coating on Aluminum and Aluminum Alloys). Table 6 lists the military specifications and their contractor counterparts which are utilized in the contractor's Finishes and Metals groups. Each specification's cost significance is indicated individually. The above example is considered a "major" impact. A "minor" cost impact would be from a few hundred to a few thousand dollars, such as, the application of MIL-F-7179 to structural tubing where the interior must be painted or coated with corrosion preventive, not a normal commercial practice.

TABLE 6. COST SIGNIFICANCE OF MILITARY SPECIFICATIONS

BAC NUMBER	TITLE	EQUIVALENT MILITARY OR HIGH ORDER SPECIFICATION NUMBERS	SPECIFICATION SIGNIFICANCE
BAC 5019	Type I (Chromic Acid Anodized Coatings for Aluminum Alloys)	MIL-A-8625	Major
BAC 5022	Type II (Sulfuric Acid Anodized Coatings for Aluminum Alloys)	MIL-A-8625	Minor
BAC 5408	Method II (Vapor Degreasing)	TT-C-490	Minor
BAC 5602	Heat Treatment of Aluminum Alloys	MIL-H-6088	Major
BAC 5609	Type III (Dow 7)	MIL-M-3171	Minor
BAC 5611	Heat Treatment of Copper & Copper Alloys	MIL-H-7199	Major
BAC 5617	Heat Treatment of Alloy Steels	MIL-H-6875	Major
BAC 5618	Carburizing & Nitroding of Alloy Steels	MIL-S-6090	Major
BAC 5619	Heat Treatment of Corrosion Resistant Steel	MIL-S-6875	Major
BAC 5621	Temperature Control for Processing of Materials	See Applicable Heat Treat Specification	Minor
BAC 5701	Type I, II or III(Bright Cadmium Plating on Steels Heat Treated Up To 220,000 psi)	QQ-C-416	Major
BAC 5706, 5776, 5745	(Zinc Chromate, Primer Application)	MIL-P-6808	Minor
BAC 5705, 5776, 5745	Material Spec. (BMS Equivalent Not Required)	MIL-L-7178	Minor
BAC 5709	(Chromium Plate)	QQ-C-320	Major
BAC 5715	(Silver Plate)	QQ-S-365	Minor
BAC 5717	Type I or II (Tin Plate)	MIL-T-10727	Minor
BAC 5719	(Treat Aluminum After Assembly, Alodine)	MIL-S-5002	Minor
BAC 5719, 5745	(Alodine)	MIL-C-5541	Major
BAC 5719	Class 3	MIL-C-5541	Major
BAC 5720	(Protection of Interior Structural Tubing)	MIL-F-7179	Minor
BAC 5726	(Treat Aluminum After Assembly, Iridite)	MIL-S-5002	Minor
BAC 5726	(Iridite)	MIL-C-5541	Major
BAC 5730	Shot Peening	MIL-S-13165	Major
BAC 5730-2	Shot Peening, Self-Contained	MIL-R-81841	Major
BAC 5734	Type I, Class C; Type II, Class D and E, (Anodic Treatment of Magnesium Alloys)	MIL-M-45202	Minor
BAC 5749	Method III (Alkaline Cleaning)	TT-C-490	Minor
BAC 5750	(Solvent Clean or Clean Any Basis Metal Covered by F-12.xxx Codes)	MIL-S-5002	Minor
BAC 5765	(Clean Aluminum Covered by F-12.xxx Codes)	MIL-S-5002	Minor
BAC 5773	Type III (Iridite 15)	MIL-M-3171	Minor
BAC 5810, Class 3	Type I (Zinc Phosphate Coating) Material Spec. (BMS Equivalent Not Required)	TT-C-490 MIL-V-173	Minor
BAC 5810, Class I	Type M, Class I (Phosphate Coating)	MIL-P-16232	Minor
BAC 5951	Glass Bead Penning	MIL-S-13165	Major

Military aircraft are frequently delivered without 100% of the approved equipment installed. This equipment is usually GFAE which does not prevent the aircraft from flying but does not normally permit mission operations. This tends to add complexity to the delivery process. The FAA regulations will not allow delivery of a commercial aircraft for revenue use without full equipment certification. This leads to a cleaner delivery with less follow-up cost.

3. Purchasing

The major effect of military program controls, specifications and standards, which must also be imposed on sub-contractors, vendors and suppliers, is centered in the Materiel Department of the contractor.

The second questionnaire answer received from one Materiel Department of the contractor is a coordinated composite of all the Materiel Department comments on this phase of the procurement cycle. Commercial aircraft materiel personnel are the buyers of all airframe equipment (commercial and derivative peculiar) on all derivative programs. The more pertinent points of this composite reply are discussed in the subsequent paragraphs. The complete reply is in Appendix G.

The cost of a purchased part for a derivative aircraft program is more than a similar part purchased for commercial programs, based on experience with derivative programs. The differences that cause the increased cost are:

(a) Small quantity buys, with greater Qualification Testing, Quality Control Inspection (contractor and government) and Production Verification Testing Requirements, spread over longer delivery periods, causing problems of shop load, high cash flow at start, and slow return of investment.

(b) A greater risk of cancellation.

(c) Lower replenishment spares potential and at very reduced pricing when compared to commercial programs.

(d) Increased cost of administration; i.e., government audits, reports, inspection, etc.

(e) Reliability (e.g., "Hi-Rel") Parts Control Program.

(f) Higher Supplier Internal Costs result from:

1. Delays caused in waiting for Government Source Inspection (GSI) to arrive and clear shipments.

2. Air Force reviews of capabilities.

3. Additional paperwork required in preparation of cost data, Form DD633 Cost Breakdown, etc., in accordance with "Truth in Negotiations" (Public Law 87-653).

(g) Special finish standards, sealants, corrosion protections, instrument lighting (different than commercial) and other requirements peculiar to military practice.

The application of government specifications to minor components that are normally purchased as a standard item in commercial work is a frequent cause of higher costs. Aircraft parts are not the only ones involved. From the CODSIA (Council of Defense and Space Industry Associations) study, "Costs Unique to Government Contracting," comes an example of the disproportionally high costs resulting from such special specifications and the purchase of small quantities (Table 7).

TABLE 7. COMPONENT COST COMPARISONS

Standard pipe fittings

	Commercial		Government	
Size	Lot Qty	Unit Price	Lot Qty	Unit Price
90° Elbow				
3 Inch	200	3.71	6	50.73
4	200	5.72	8	79.82
6	200	14.46	26	160.20
8	50	26.41	1	186.82
10	25	48.76	1	226.34
Tees				
2½	15	4.35	1	64.94
3	10	5.85	18	20.16
4 Inch	20	8.20	1	65.48

Suppliers more often are reluctant to bid on parts for military programs because these programs:

(a) May "tie up" engineering talent on a small volume of business. They wish to use such personnel in areas of greater return.

(b) May "tie up" equipment on a small quantity military when it is needed for the manufacture of similar commercial parts.

(c) May have to compete with the supplier now producing a similar part. (Small quantity releases again.)

(d) May have to add the staff to handle the additional paperwork required by government procurements, i.e., added testing, reporting requirements, government audits in all areas, deletion of costs per ASPR XV, etc.

(e) May have to obtain the financial reserves to cover the additional time taken for government to make purchasing decisions.

(f) May be terminated from the procurement because of factors outside the customer's control.

(g) May submit many proposals which never lead to orders (exercise on RFP's, ECP's, etc.).

(h) May encounter schedule slides caused by the uncertain funding by Congress.

(i) May have to change internal business systems to accommodate the regulations, procedures, Terms and Conditions, etc., which they must "flow-down" to their lower tier suppliers.

An experience on derivative programs illustrates this problem. The requirement on one derivative program for an item of AGE could be filled with available off-the-shelf commercial ground support equipment. This equipment had been purchased commercially off-the-shelf for the E-4A derivative aircraft. However, the new purchase order included the prime military contract flow-down. When it arrived at the manufacturer, he refused to accept it. The reason given was because the order for this off-the-shelf item was accompanied by a list of specifications of which he did not have copies nor the available staff to interpret and comply with the documentation and accountability requirements. A compromise was reached, and a prime contractor team helped match the hardware and documentation with the requirements.

E. TESTING

Testing includes shop, ground and flight testing which occurs during the design and production of an aircraft. The effort in this phase of Task II includes identifying differences in test and evaluation practices and a gross evaluation of both component testing and flight testing. The practices evaluated are decision-making processes, manloading, number of test hours or time required, phasing into the program (lead time), extensiveness of test plans or specifications, average number of pages for documenting test results, and policy for design changes as a result of tests conducted.

Airworthiness is established in a similar manner for both programs. The greatest difference in test programs is the military requirement for formal demonstrations of reliability, maintainability and logistic support. In lieu of formal demonstrations, commercial programs obtain this information from early in-service operations. Other smaller differences result from more stringent military requirements arising from the anticipated more severe military usage. These include additional structural testing and climatic testing. The added complexity of the military mission equipment requires more testing for the additional avionic and other special sub-systems.

Another difference noted is that the military requires interim approval of test procedures and plans, as well as final approval of test results, while commercial programs require approval of final results only. (Figure 18 shows a typical commercial test requirement form - one page.)

1. Flight Testing

The Air Force Flight Testing Program is organized and managed in accordance with AFR 80-14 or 80-36, depending on whether it is a purely military or commercial derivative. It is conducted to satisfy the requirements of the military specifications for air vehicle, its subsystems and the ground support systems which are reflected in the aircraft design specifications.

The commercial program must satisfy the requirements of FAR-25, Airworthiness Standards: Transport Category Airplanes. These requirements are primarily intended to establish that the aircraft is safe. The test program also must demonstrate to the customer(s) the guarantees for cruise performance, fuel consumption, etc.

747 TEST REQUIREMENTS

TEST PLAN NO. [illegible]

APPLICABLE 747
-100 ☐ -200B ☐ -200C ☐ -200F ☒
1ST OF A MODEL ☐ OTHER ☐

TEST TITLE
Body Proof Pressure Test

TEST TYPE
LAB ☐ A.P G1 ☒ A.P FT ☐

TEST REQUIREMENT
TECH DISCIPLINE: Structures
(AERO, STRUCT, PROP, ETC.)
RESPONSIBLE ENGR J. Wood/L. Craig

CHECK ONE ONLY
- DESIGN DEVELOPMENT ☐
- DESIGN VERIFICATION ☐
- CERTIFICATION ☒
- PRODUCT IMPROVEMENT ☐

REF. NUMBER
- CUST SPEC
- FAR No. 25.307
- OTHER

SENIOR STAFF/PROJECT ENGR
Approved: J. M. Hov Date: 7/21

747 CHIEF ENGINEER-TECHNOLOGY
Approved: Date: 4/23/70

EWA No.
1-1-71
Date Req'd Rel'd

TEST PRIORITY (SEE PROJECT MEMO 9.1)
MANDATORY ☒ CRITICAL ☐ IMPORTANT ☐ DESIREABLE ☐

TECHNICAL TEST OBJECTIVE
1. To satisfy the FAR requirement for substantiating load tests.
2. To verify internal structural load distribution.
3. To demonstrate by test, structural capability beyond shop pressure test requirements on the production line.

TEST DESCRIPTION (INCLUDE DATA REQM'TS)
1. Pressurize the airplane to 14.0 psig.
2. Record strain gage and deflection data at incremental loading of 1.
3. Read photostress data at incremental unloading of 1.

UNIQUE TEST VEHICLE/FACILITY/EQUIPMENT CONFIG REQM'TS (INSTR, A/P, TEST RIG, ETC.)
747-200F

TEST SCHEDULE
- TEST CONDUCT PERIOD 8/3/71 thru 8/12/71 (3 shifts)
- TEST RESULTS REQ'D/SCHEDULE CONSTRAINT DATES Prior to first flight of freighter
- DATA SUBMITTAL DATE (FAA Cust) • REPORT, DOC. No., ETC

ESTIMATED BUDGET REQUIREMENTS
Approved: Date: 4/23/70
- ENGR 1,500 (M/H)
- MFG 3,000 (M/H)
- MATERIAL $ 10,000

BOEING
Section 3.7
NO. D6-30502-1
PAGE 3.7.4
6-7000

Figure 18. Typical Commercial Test Plan

The military Category I flight test program accomplishes essentially the same test objectives of flying qualities, performance, and system qualifications as the contractor evaluations in the commercial program. The FAA demonstration is similar to the Category II performance and systems testing. Additionally, the military program introduces into Category II, testing for system integration and accelerated service testing. Category III has no formal equivalent on a commercial program.

Comparison studies have been made of flight test programs for commercial and military versions of the 737 and 747 aircraft. The studies indicated approximately 25 additional flight hours would be needed during Category II to make an FAA-certified aircraft comply with the military specifications. (The T-43A program was required to comply with the additional requirements while on the E-4A they were waived.) Summaries from the studies are contained in Appendices H and J. Comparisons of equivalent testing and total pre-operational flight programs are shown in Tables 8 and 9. The major differences are in reliability, maintainability, accelerated service testing and training. Since these are Category II and III requirements and performed by the customer, quantifiable cost data is not available.

TABLE 8. FLIGHT TEST PROGRAM COMPARISON - FLIGHT HOURS

Item	Commercial		Military	
	Design proving & development	FAA cert. demos.	Cat. I	Cat. II
Preliminary evaluation	30		30	
Performance	89	100	95	110
Stability & control	95	54	105	65
Engine & fuel	20	26	25	30
Systems	105	78	125	105
Structures	55		75	
Acoustics	8	1	10	5
Functional and reliability		150		
• System integration and maintainability				190
• Accelerated service testing				780
Non-test flying	120		70	
Total	522	409	535	1385

TABLE 9. PRE-OPERATIONAL FLIGHT PROGRAM - FLIGHT HOURS

	Commercial	Military
Flight test	931	1920
Contractor crew training	900	
Customer crew training and route proving	800	1885 (Cat. III)
Total	2631	3805

During a special cost reduction effort on the E-3A program, the flight test activities were reviewed for potential savings. The review was made by assuming the program would be completed using the same procedure as is employed on commercial programs when a new model of the same type is tested. This procedure utilizes all available past experience and like design test points. For example, the Air Vehicle Testing would not include a complete flight loads survey. Only a few points would be checked to assure that the new model is the same. If these points did not track, then the test would be expanded as necessary. The same would be true in other areas where little or no design change has been made, e.g., the landing gear, wing, etc. Other cost savings would be achieved by not reducing recorded data unless a problem arises. Although data is recorded on commercial test flights from engine start to engine shutdown, it is only reduced when required to observe trends or to investigate potential problems.

The Mission Avionics testing could be reduced by accepting previous test results where no changes had been made in the sub-system or by merely testing the changed or modified parts within the sub-system (both standard commercial practice). The Environmental Suitability flight testing could also be reduced by accepting data availability from previous tests or by combining it with other tests.

Reduction in program length could also result from the modification of the military regulation requiring 24-hour crew rest between test flights. (Commercial flight crews follow normal working day requirements.) Another reduction could come from not restricting contractor crew members to just one derivative model. The contractor's test pilots and crews are qualified to fly all currently produced models and do so; i.e., the 747 one day, the 727 the next, and so on.

A Value Engineering Change Proposal (VECP), was submitted to reduce the flight test program by 603 flight hours and 25 months. See Figure 19.

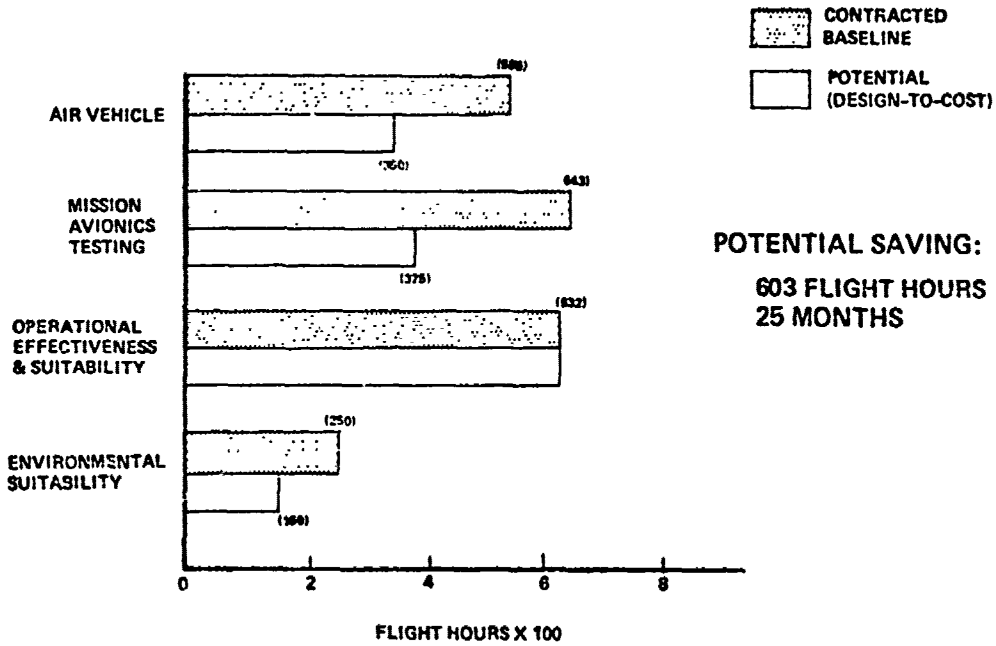


Figure 19. Flight Test Program

The VECP was not approved for the following reasons:

a. Flight Hours - The main difference in flight hours is that military requirements are aimed for the worst known case while commercial requirements are aimed at margin over anticipated use and take advantage of other data.

b. Calendar Time - One reason for extended calendar time rests with the 24-hour crew rest requirement. For example, if the crew members complete a test at 1600 hours, they cannot fly until 1600 next day. If the next test is a daylight test, it is scheduled for the next daylight period, another wait of 16 hours. Testing new military aircraft, where everything is new and different, is a different experience. All faculties of the personnel need to be at high performance due to high risk factor. But on derivative aircraft, where contractor pilots are very familiar with the basic aircraft, the risk is less. Consequently, the crew rest time can be decreased. MAC uses 15 hours crew rest without jeopardizing safety. The rationale for the 24-hour rest time should be reviewed for derivative aircraft.

The cost of a flight test program for a military derivative of a commercial aircraft is increased by application of the requirement to comply with Air Force Regulation (AFR) 55-22, CONTRACTOR'S FLIGHT OPERATIONS. This regulation requires contractors, who operate aircraft "for which the government assumes contractual liability for loss or damage," prepare and follow procedures which comply with its requirements and which are approved by the Government Flight Representative. The application of this regulation could be tailored toward commercial practice for derivative aircraft.

Areas which need tailoring are:

a. Form 24 Approval by USAF - This personnel flight clearance form requires SPO approval for all USAF personnel, Contractor approval for his test personnel, and AFPRO approval of the completed form. Approximately three-fourths of all forms are changed after initial approval (generally for a change in personnel) and then require additional coordination. Compliance with this requirement expends six to eight manhours (engineering/engineering supervision) for each scheduled flight on one derivative program. On a commercial flight test program the requirement for flight clearances is checked by the responsible test engineer. Much lost time could be saved by delegating this approval authority to military personnel on duty or to the responsible contractor test personnel.

b. Flight Physicals - The flight physical examination requirements are basically the same, but the regulation does not allow personnel who are required to fly only on occasional flights to do so without a flight physical, a standard commercial practice. This increases the number of physicals required by 30 to 40 per cent. This requirement is often waived for VIPs.

c. Physiological Training - The regulation requires that all personnel obtaining a flight clearance have physiological training including the altitude chamber test, even on a derivative aircraft. A typical example of this requirement was the T-43A Navigator Trainer, where the structure and the pressurization system are identical to the commercial 737 aircraft. The same situation is essentially true on the E-4A, E-3A and Peace Station (707 derivative for IRAN). This requirement is also waived for VIPs.

d. Flight Clothing - This requirement states that all test crew members must wear Nomex flight suits, gloves, and boots. The Nomex flight suits and gloves are in case of an inflight fire. The boots are in case of bail out. None of the current military derivative aircraft is equipped with bail out systems or with parachutes. This requirement is waived for VIPs.

The savings that could be realized by tailoring this regulation are shown in Section V.

3. Ground Testing

Another specific example of differences in testing between military and commercial aircraft programs is in the flight deck instruments lighting. A VECP was submitted to use commercial standards in lieu of MIL-L-27160B, "Lighting, Instrument, Integral, White, General Specification For." To perform the test per MIL-L-27160B, special equipment is required to record data not visible to the naked eye. (Commercial tests do not have this requirement.) A comparison of the differences is shown in Table 10. The portion of the VECP covering the E-3A flight engineer's panel instruments was approved, saving $157,312.

TABLE 10. TEST COMPLIANCE - INSTRUMENT LIGHTING

Each instrument	Mil-L-27160B	Commercial
Lab. technician test time	10 Manhours	5 Manhours
Computer program and report	10 Manhours	6 Manhours
Computer time	2 Minutes	0 Minutes
Rejections (and retest)	5	1

In summary, some flight test costs on derivative aircraft can be reduced by carefully tailoring the test requirements to make maximum use of existing commercial practices and data.

F. OPERATIONS AND SUPPORT

Operations and Support includes maintenance and operations, contractor support, supply, manuals and training. Maintenance and Operations includes off-equipment repair, on-equipment repair, new item inventory management, operations personnel, maintenance personnel and fuel. The effort in this phase of Task II consisted of identifying significant differences in the operations and support practices for fielded programs. Major differences were evaluated in areas such as maintenance concept employed, support equipment and facilities, spares provisioning points. technical data/handbooks, and extent and level of training required.

1. Operational Support Requirements

Only infrequently do contractors provide the airlines with something approaching an "Operational System," as the Air Force uses the term. The airline contracts usually specify an aircraft with specific performance requirements. The other elements of an aircraft system, such as

facilities, ground equipment and personnel are generally defined by the contractors but are procured separately by the airlines and the airport authorities. Many of the military system engineering techniques intended for application to support functions are consequently performed by the commercial customer rather than by the airplane manufacturer. When the contractor analyzes system requirements for a military aircraft system, it is the mission systems and ground functions, particularly, which require system engineering techniques, such as, cargo loading, weapon loading, fueling, engine removals, etc. These techniques depend upon compatibility of aircraft with ground equipment, procedures and personnel.

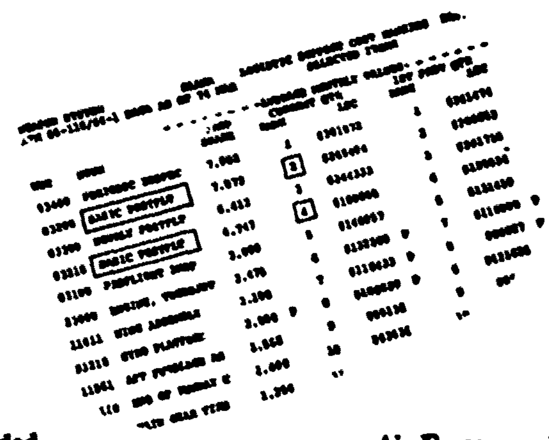
2. Maintenance

The airlines continually review the need for maintenance without jeopardizing safety. New advanced techniques and procedures are constantly being developed. The airlines have shared these new techniques with the military. Although the benefits to date could be larger, they may be limited because of the military operation of many types of complex aircraft; the constantly changing, somewhat less experienced labor force; and the low utilization geared to provide weapons systems for deployment.

A review of many Air Force maintenance programs shows that over 30% of the logistics support costs are in scheduled maintenance - inspection. (Figure 20 is typical.) Over one-third of that labor is expended on

Scheduled Maintenance

Statistics



Derivative Program

Contractor recommended

- Preflight
- Thruflight
- Weekly postflight
- Phased isochronal
- Iran

Air Force requirement

- Preflight
- Thruflight
- Basic postflight
- Weekly postflight
- Phased isochronal
- Iran

Figure 20. Logistics Support Costs

basic postflight inspections. A maintenance schedule, typical of commercial programs, was proposed for the T-43A which did not include this type of inspection. The customer requirement included it. A comparison on the scheduled maintenance for the proposed and actual for the T-43A derivative aircraft and the actual on its commercial counterpart is shown in Figure 21.

Scheduled Maintenance Labor – T-43A / 737

INSPECTION TYPE	INTERVAL	DOWN TIME	MH/FH PROPOSED	MH/FH ACTUAL
PREFLIGHT DAILY *	DAILY DAILY	1 1	1.62	1.08 1.60
POSTFLIGHT A	EA. FLT 65 FH	1 3	–	0.80 0.20
WEEKLY B	7 DAYS 250 FH	2 8	0.78	0.78 0.18
ISOCHRONAL C	35 DAYS 1000 FH	6 24	0.90	0.90 0.55
IRAN ** D	12,000 FH 12,000 FH	240 168	0.54	0.54 0.54
TOTAL			3.64	4.10 3.07 = +12%

* INCLUDES ALL LINE MAINTENANCE ALSO KNOWN AS TERMINAL, OVERNIGHT, PREFLIGHT, ENROUTE, ETC.

** PERFORMED BY CONTRACTOR

Figure 21. Maintenance Labor - T-43A/737

The current airline maintenance planning technique, defined in the "Airline Manufacturer Maintenance Program Planning Document, MSG-2," was developed by representatives of various airlines and includes decision logic and interairline/manufacturer procedures for developing a maintenance program for new aircraft. The objective of MSG-2 is to present a means for developing a maintenance program by outlining the general organization and decision processes for determining the essential scheduled maintenance requirements for new aircraft. Its approval by the FAA Maintenance Review Board (MRB) is estimated to provide a 45% reduction in scheduled maintenance labor from its application to the 747 program, as shown in Figure 22.

Scheduled Inspections
(Routine Tasks Only)

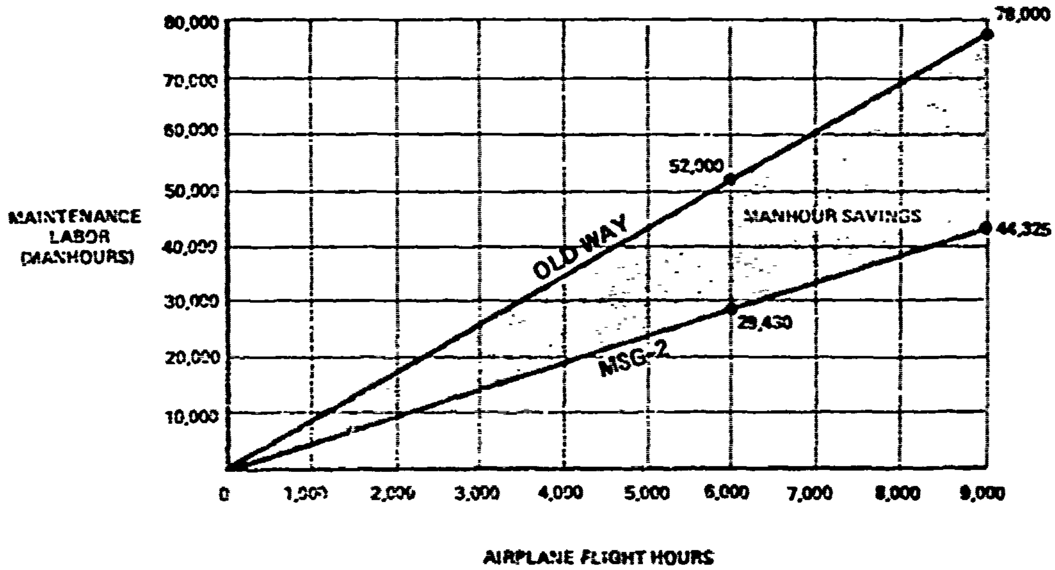


Figure 22. MSG-2 Manhour Savings - 747

MSG-2 has been reviewed by the military logist. . personnel. High level officials of DoD have been briefed on its use by the airlines and the contractors. Ammendment #1 to MIL-M-5906D, "Manual, Technical, Inspection and Maintenance . . .," which changes the inspection planning section and incorporates MSG-2 in the Appendix, is currently in review. AFLC has let a contract to the contractor to apply the philosophy of MSG-2 to the B-52 inspection program and to determine the savings available, estimated at 25%. The philosophy of MSG-2 is also being utilized in E-3A maintenance planning, saving estimated at 28%.

The T-43A logistics support program included one feature which is resulting in a great savings to the Air Force. Instead of using the traditional jet engine philosophy of hot section inspection and overhaul, an engine IRAN type program called Engine Heavy Maintenance (EHM) was included and accepted in the Contractor Support Package. The cost impact of this practice is described in Section V.

Another commercial airline practice recommended and applied to the T-43A program is called engine derating. This procedure, implemented by commercial airlines to reduce failures and thus save money, allows a reduction in takeoff thrust on occasions when conditions of weight, temperature and runway length permit. (The reduction in peak engine temperature improves engine life.) Approximately 50% of all airline departures are at reduced thrust. The summary of these benefits is shown in Section V.

3. Contractor Support

The advent of derivative aircraft increased the application of contractor support programs. Contractor Support is basically the performance of military support functions by commercial companies. The method of operation is to have the government decide the organic level of support to be accomplished; then contract the remainder to the prime contractor for accomplishment. The support can include on-base support functions and generally includes spare part provisioning. The government also requires performance guarantees backed by penalties and incentives. The key item is a single contract with the prime contractor who, in turn, has existing commercial airline industry support.

Most logistics support contracts have been written for derivative aircraft because of the availability of airline support and because the programs have been non-tactical. The use of such support during the production phase of a military aircraft has been advocated in the past and could work as shown in Figure 23. Continuation of support after

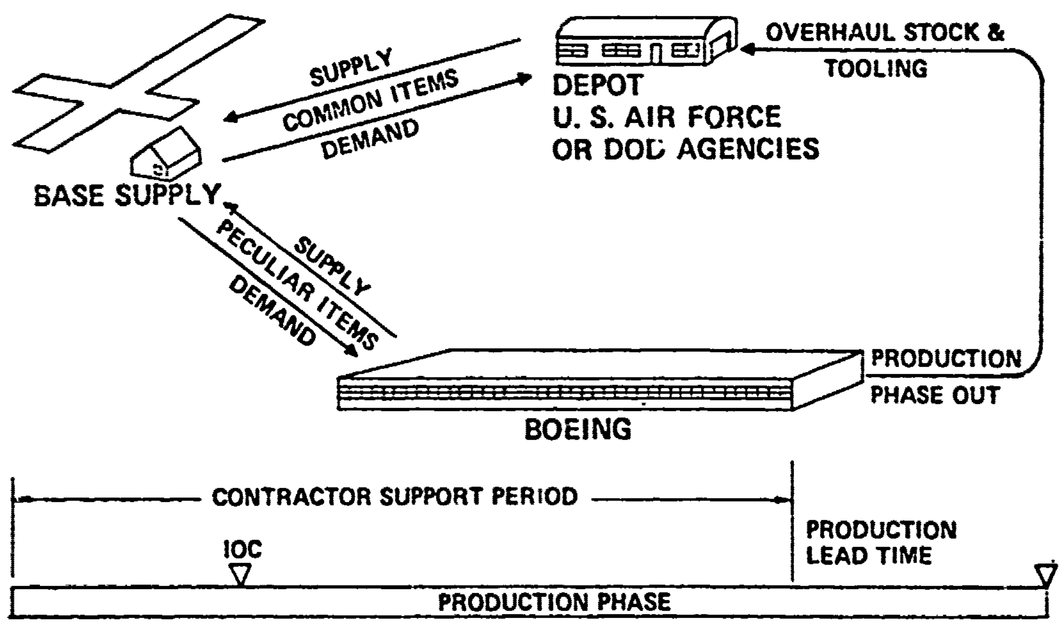


Figure 23. Contractor Support - Military Aircraft

the end of production would offer the benefits of having (1) a production capability in case of emergency, (2) lower non-recurring costs for producing additional aircraft if needed, (3) wartime support capability available almost immediately, and (4) a transfer of activity from the DoD payroll, which now takes more than 60% of the budget due to salaries and retirement benefits, to the private sector of the economy. The logistics savings estimate is approximately 40% although a detailed study has not been conducted to verify this estimate.

The savings from contractor support on derivative programs result from fewer spares (including insurance items), use of commercial publications, fewer maintenance personnel, less AGE, quicker part overhaul, fewer inspections and use of airline work force capability.

The greatest potential for cost-saving in contractor logistics support is the provision of spares by the contractor during the early years of a program. Statistics from previous contractor and Air Force studies show that about 50% of initial spares become obsolete or are never used. Besides the obsolescence factor of parts, at least 50% of initial Federal Stock Numbers (FSN) expense could also be avoided. The supply system savings of contractor support also result from higher volume of the commercial system and from a shorter pipeline. Two studies were made on this supply cost saving: on the potential use of the 747 as a tanker and on the Utility Tactical Transport Aircraft System (UTTAS) helicopter. Both studies indicated a 40% saving (See Section V).

Technical publications afford cost savings of an estimated 78% since use of commercial manuals permits the government to become one of many customers instead of a unique one.

The maintenance labor cost is reduced 28% because the greater number of personnel required under the military system more than offsets the higher cost of civilian aircraft maintenance skills.

The elimination of Aerospace Ground Equipment (AGE) from the shops and from the depot results in approximately 80% savings in AGE equipment and support costs.

The contractor has gained experience in the operation of the support elements of military bases and now has data which points to a potential 50% reduction in personnel costs by the utilization of Contractor Support. The yearly cost of the average skill level within a support group now favors the concept of contractor support. A manning comparison is made for a transportation squadron. The reduction results from the deletion of military duties (20%) and the work improvement (23%-30%) benefits resulting from less paid training, multiskill capability, personnel longevity and profit motivation. The cost impact is shown in Section V.

The application of the contractor support concept to an individual aircraft program must be made at the program inception. The many variables of the concept must be evaluated, reviewed and applied in accordance with the program mission, availability of both organic and contractor support, budgetary considerations and socio-political pressures. What works well on one program may not on the next. Experience to date has provided sufficient evidence that the application of contractor support to derivative programs is cost-effective. It is, however, an evolving practice and application to each program must be considered relative to program uniqueness and goals.

4. Supply

Comparisons of basic differences between Air Force and commercial spares provisioning concepts have been made from time to time at the request of both military and commercial customers. Both customers are seeking a better way to solve a tough problem - how to get the most for the investment. Identification of "differences" is not intended to imply that all commercial practices are preferred nor that they could logically be applied to every Air Force program. It is considered highly desirable, however, that each new program be matched with the most efficient and effective support program by careful selection of the organic/industry responsibilities and the related procedures. Table 11 compares the basic differences which are detailed in the following paragraphs.

TABLE 11. SUPPLY COMPARISON

Commercial	Military
Industry common parts	Unique parts
Share facilities and tools	Own all facilities and tools
Borrow to solve AOG	UC dependent on depot
Repair/overhaul to servicable	Overhaul to zero time
On condition parts removal	Fixed time parts removal
Short pipeline	Longer pipeline
Spare parts general term agreements	Competitive bidding
Warranties	No warranties
Limited stock numbering	FSN on all parts

The amount of in-house repair, and hence the investment in tools, test equipment, overhaul components, and shop manpower, will vary widely among the operators. In general, the larger the operator's fleet, the more prone he will be to perform component overhaul and repair. With the advent of jet aircraft, the larger operators have shown an increased tendency to share these facility investments through agreements with each other and to assume responsibilities for specific aircraft systems in behalf of all members of a consortium. The operators with small fleets frequently subcontract to the larger operators for support of items requiring a significant investment in repair facilities. Typical of this is the investment required to overhaul and test the current series of large jet engines.

The cost associated with construction and equipping an engine test cell cannot easily be justified unless a large number of engines are expected to be processed through the facility. Similarly, the cost of a spare engine is so great that replacement power plants must be minimized, which in turn, forces rapid repair and return to service of failed units. In order to accomplish this rapid turnaround, the "modular maintenance" concept is employed, but this imposes a significant investment in spare modules. By increasing the fleet size to be supported through agreements among the operators, the fixed costs and many of the investments not affected proportionately by the number of end items being supported can be effectively spread across a larger base, thus reducing the cost of ownership for all concerned.

Commercial carriers, although competitors for routes and passengers, have historically cooperated with each other when equipment problems exist. Critical parts appropriately marked will be given priority on almost any airline in the world to alleviate any other operator's AOG (Airplane On Ground - same as NORS-G). Borrowing from stocks of different operators at a common station is common practice. The basis for this cooperation appears to be the bilateral respect and trust that exists among the commercial carriers. Each has assurance that, should the role of recipient and supplier be reversed, the results would be unchanged. By contrast, the Air Force has expressed a desire to utilize commercial assets as back-up to its organic capability but has not entertained an agreement whereby the commercial operator can extract the equivalent support from Air Force supplies.

Other differences between Air Force and industry support concepts include the degree to which overhaul/repair is performed. Generally speaking, the Air Force attempts to "zero time" its components returned to an Air Logistics Center (ALC) for overhaul. Some years ago the commercial operators departed from this procedure and now, generally, perform repair/overhaul to the extent necessary to return the item to a "serviceable" condition. Various airline studies have revealed that complete overhaul often degrades reliability and may incur expenditures greatly in excess of the cost required to simply repair as necessary to meet service requirements. This change in concept occurred at about the same time that the airlines (and in government, to a lesser extent)

all but abandoned the programmed removal of components based on installed flying hours. It was established that monitoring the performance of these items in order to detect potential/incurred failures improved reliability and simultaneously decreased costs by minimizing overhaul/repair costs and the failures attributed to "infant mortality," reintroduced at each repair cycle.

Involvement of the prime aircraft manufacturer and responsible major suppliers is also encouraged by the commercial operators. To this end, commercial airlines may pay higher unit prices for selected spare parts than would the military for an identical item. The commercial price recognizes the supplier's expense and economic exposure in providing for a stock of parts at his facility in order to fulfill customer orders with a minimum of reorder lead time. This supplier capability obviously reduces the depth (and sometimes range) of parts requiring airline investment and makes maximum use of the "pool store" concept for the support of all operators. The collective costs for each airline to provide for its own individual parts support equivalent to that gained through the supplier pool(s) would be prohibitive in view of the comparatively small increase in operating costs which allows the pool store(s) to exist.

Commercial support programs often are defined by a "Spare Parts General Terms Agreement (GTA)" which sets forth the procedures and exclusive terms and conditions governing the supply by the prime manufacture and procurement by the airline of all spare parts procured through the prime contractor. As opposed to the government AFAD's, the GTA imposes obligations on the Buyer as well as the Seller. It addresses such items as agreements to manufacture and sell; agreements to purchase; pricing; leasing arrangements; ordering procedures; title and risk of loss; inspection and acceptance; warranties and re-purchase agreements. Provisioning data to be submitted is basically at the contractor's discretion, although Air Transport Association Specification #100, "Specification for Manufacturer's Technical Data," establishes a standard for presentation of supporting data such as Illustrated Parts Catalogues, Maintenance Manuals and Illustrated Tool and Equipment Manuals. Lacking in the commercial environment is the preparation and continued revision of a multitude of provisioning data elements which significantly complicate Air Force procurement programs. AFAD-688 and its related Data Item Descriptions have, in some instances, involved submitting provisioning data in great detail, supported by complete drawing coverage of each item of an assembly, even though procurement of the parts or spares was neither recommended nor accomplished. Repeated submittals are generated as a result of continuing design change action. During the early 1950's, MCP 71-673 provided for Resident Provisioning Team (RPT) activities in behalf of the government within the contractor's facility. This was more nearly akin to the commercial practices of providing a small group of highly qualified provisioning specialists to make decisions and commitments which result in the support posture desired. Some recent programs appear to have abandoned the RPT in favor of the former practice involving additional coordination and documentation. The airlines have not yet economically justified this effort and therefore have not adopted this military practice.

Government regulations, which may restrict the Air Logistics Center's mode of procurement, are not evident in the commercial environment. Specifically, the need to compete the re-procurement of spares is not a requirement. Again, the economic value has been weighed by the airlines, and the costs of competing each procurement of replenishment spare parts has not been economically justified. Some factors influencing this assessment are the cost of preparing and transmitting Requests for Proposal; the cost of review and analysis of bids; the qualification of unapproved sources; the increase in re-order lead times necessitating increased stores investments; the voiding of commercial warranties due to incorporation of bogus parts; procurement of equivalent assemblies requiring different sets of maintenance/overhaul parts, manuals, test equipment and training; and other very real costs attendant to this form of procurement. This does not imply that competition does not exist for airline business, because it surely does, but the determination of when to use the longer, more expensive forms of procurement is a function of the comparative economic advantages rather than procurement regulations.

The commercial programs do not usually require or assign identification numbers equivalent to the Federal Stock Number (FSN). Some operators do assign their own part number in order to simplify computer programming and to standardize their inventory management procedures, but an analysis of the item as accomplished by a Federal Standard 5 would only be entertained in the event the operator determined that generation of his own "standard" would serve a useful purpose. It is believed that this could be a consideration only on items with a high probability of commonality to other aircraft in his fleet and would not be accomplished on basic airframe components peculiar to a given prime contractor's specific aircraft model.

5. Manuals

Many differences and factors were cited by Logistics managers relative to cost difference between contractor commercial and contractor military technical manual programs. However, most of the military controls stipulated in military specifications have been proven necessary, due to the many contractors who may have less experienced technical manual personnel and who are required to supply technical manuals to DoD. This is another example where tailoring the requirements of the government to the program and to the contractor can result in cost savings.

The military manual requirements reflect the military desire to achieve an integrated system. Operations/Maintenance analyses, engineering solutions, equipment (AGE) solutions, ECP proposals, and other AF procurement, which are reflected in TOs, require much effort. Also the system is iterative, which requires tracking changes to maintain configuration.

Commercial maintenance manual (MM) costs are lower due mostly to savings in the quality assurance area. Table 12 shows which military TO quality assurance requirements (flagged and underlined) are over and

TABLE 12. MILITARY TECHNICAL MANUAL QUALITY ASSURANCE

"Baseline" criteria	In-house controls	Reviews	Validation/ verification
• Contract AFADS/1423s	• Tech manual development controls	• In-house	▷• TO 00-5-1
• Mil specs/stds		Engineering	• In-house
• AF regs/exhibits		QA	Production line
• Planning docts	QA manual and checklists	Management	Engineering
Program plan	Management	• Air Force	▷ Validation
Tech manual outlines	• Configuration control	▷ Pubs plan	• Air Force
		▷ TO outlines	▷ Verification site (Air Force base)
• Configuration documents	Engr. drawing/ to configuration relationship	▷ 40% and 80% in-process	▷ Test programs (IOT&E) (OT&E)
	ECPs	▷ PDR/CDR	Deployments
		▷ Pre-pub FAC/PCA	AFTO Form 22's

▷ Not commercial ATA100 requirements.

above commercial ATA-100 MM requirements and cause higher costs. Thus, the commercial manpower level-of-effort per page is considerably less than a comparable new military TO page. On the T-43A program the use of commercial format in the maintenance manuals saved approximately $70,000 (66%). ATA commercial MM's maintain accuracy by the mechanized assignment (configuration) and product controls which do basically the same job with less data and effort. ATA-100 does not specify detailed QA "proofing" requirements as does the AF Technical Order Systems Quality Assurance TO, 00-5-1 (AFSC Form 11's, AFTO Form 158's, In-Process Reviews, V/V Plans, etc.). The verification part of TO 00-5-1 can be a problem. On one derivative program, maintenance procedure verification ties up the aircraft with shop support for six days.

The premise that commercial aircraft MM's can be equated with military organizational maintenance manuals on a page-per-page cost basis is true for those manuals prepared in accordance with MIL-M-25098, Handbooks Organizational (Flight Line) Maintenance Instructions (Aircraft). This specification, similar in content to the ATA-100 MM specification, has been dropped from the latest USAF MMOMP Spec List Exhibit, and its successor, MIL-M-38800, Organization Maintenance (for Aircraft), cannot be equated with the current ATA-100 Specification because of a completely revised format and content. If manuals for derivative aircraft were to be required in military specification format and content, compliance with MIL-M-38800 would require a complete new writing. If MIL-M-25098 were still in effect, the commercial manuals would require much less effort to convert. The difference between commercial and MIL-M-38800 manuals is approximately eight times the size and four to five times the cost. This is because MIL-M-38800 requires much greater detail for use by 3-level technicians.

Microfilm is used extensively in the commercial industry. Benefits include decreased manpower for revisions, better accuracy in incorporating the revisions, and minimal space requirements. Many studies have been made by and for the government concerning the use of microfilm. Improved reader/printers on the flightline could make military microfilm usage in the field more practical.

The biggest potential for savings in technical manual development in a large weapon system program lies in the Integrated Data Concept. Three pages from the contractor-prepared Exhibit 437A-72-000/A for the Bare Base System 437A explain this concept and are included in Appendix K. One USAF program (F-15) is employing this concept but its experience data is not available. Excessive duplication of operation and maintenance information development is being avoided.

6. Training

In general, training of airline maintenance personnel is accomplished in much the same fashion as on military programs. Both customers send their best and most experienced people for familiarization and systems-oriented maintenance training at the contractor's facility. Once trained, these personnel return to their organizations to train other maintenance personnel. Normally, this training is formal classroom type training, either at the home base or at a training facility. However, since new commercial aircraft tend to represent smaller state-of-the-art advances, the aircraft sub-systems and their maintenance tend to be similar to that accomplished in the past. This fact, coupled with higher airline retention of skilled personnel, permits commercial maintenance training to be less formal than for comparable military programs.

Commercial airlines are able to accomplish all maintenance training using three or four basic courses, whereas the Air Force may have to use 10 or 12 courses for the same areas. This results, primarily, from the difference in the personnel classification systems. Each classification requires a different course. Total content of both military and commercial courses is the same. The adaptation of existing training data has been in evidence in some derivative programs but absent in others. The use of courses in the commercial format, but arranged into the appropriate military skills, reduced training costs on the T-43A program without degrading the quality of the training.

The principal difference between military and commercial training methods for flight crew members is the philosophy of teaching employed. The military tends to continue with the concept that each crew member requires detailed system information whereas commercial operators train on the "need to know" basis. The new policy in the military incorporates this philosophy although no programs are known to be using it at this time.

The cost of training pilots is regarded as a non-productive item in the airlines' budgets. Consequently, everything possible is done to reduce flight training costs but still maintain pilot proficiency. Table 13 shows a comparison of current airline practice with that utilized by

TABLE 13. TRANSITION TRAINING - TRANSPORTS
EXPERIENCED PILOT TO NEW AIRCRAFT TYPE

	MAC	AIRLINE
GROUND	160 HOURS (1 MONTH)	120 HOURS (1)
SIMULATOR	20 HOURS	17-20 HOURS
FLYING		
LOCAL	40 HOURS (2)	0.5-2.0(3)
ROUTE	2-20(4)	5-10(5)

(1) Can be reduced by simulators, procedures trainers, audio/visual devices.

(2) Consists of 20 in left seat plus 20 as observer.

(3) Time is determined by what it takes pilot to make normal take-off and landing, engine-out take-off and landing and a missed approach.

(4) Consists of local check ride plus ACM duty on normal productive flight.

(5) Consists of two productive flights with IP in other seat.

MAC, both assuming that qualified jet pilots are being checked out as co-pilots (third officers) in new equipment. Since training flights use fuel and parts non-productively and since accidents do occur during this phase of operation, the actual flight time for airline pilot upgrading and proficiency is reduced as much as possible.

In current conventional military flight training programs, presentations in the ground training school are oriented toward airplane systems such as flight control, navigation and fuel, and instructions are given in extreme detail. Although this method is considered to have merit in terms of manual backup training for degraded system operations, it imposes on the aircrew an unnecessary major transition from systems knowledge to procedural actions as they progress toward simulator and flight training. To overcome this shortcoming, a program was initiated to study the feasibility of training entirely by procedural blocks and providing, as required, some systems information as to "why's" for each procedural step. This effort resulted in elimination of irrelevant information, the improvement of training continuity and the standardization of performance evaluation or terminal behavior of the trainee. This method is called Specific Behavioral Objectives (SBO).

The SBO are a complete and detailed listing of the terminal behaviors required for each member of the flight crew to accomplish all normal, non-normal and emergency operational procedures and of the criteria required for evaluation of performance.

Military aircrew training could emphasize use of cockpit procedure trainers and simulators to reduce flight hours and thus lower training costs. The contractor training of about 25 percent of the airline crews for the 747 aircraft tends to preclude tie-up of initial aircraft deliveries for pilot training, as is the normal practice for military aircraft. For example, typical planning for large military transport programs require assignment of six aircraft for aircrew training exclusively.

7. General

There is a difference in support provided to the military and commercial customers. Generally speaking, commercial program contractors afford more product support to the customer than does a military program contractor, probably because it is part of the prime system procurement package. For this reason, the commercial customer will generally expect and receive more assistance.

The outline beginning on page 72 lists the contractor's maintenance, facilities, equipment, spares, and training activities supporting a 737 purchase, similar for all commercial airplane purchases from the contractor. These activities can be paced by the sequence of the contract, production, and delivery events listed in the left-hand columns. The diary is intended to be general, and content, as well as the chronological order of activities, may vary to fit the individual customer's needs.

The activities noted in the following pages take place after the customer has made a decision. Prior to that time, the contractor makes available every service to assist in performance evaluations, route analysis, economic analysis, traffic analysis, and complete fleet planning services, including consideration of aircraft already in service.

These services are or could be available to, and could be utilized by, the government if the recommendation to have contractor participation in the concept definition phase and on the review of RFPs is implemented.

Before Manufacture

AIRPLANE PURCHASE, PRODUCTION, AND DELIVERY	MAINTENANCE AND OPERATIONS	FACILITIES AND EQUIPMENT	SPARES	TRAINING
PROPOSAL. A letter defining the general terms for airplane purchase is presented to the airline	AIRPORT TESTING. If desired, Boeing can investigate candidate runways onsite and establish airplane/runway compatibility. An analysis document is submitted to the airline for use with the regulatory agency			
PROPOSAL ACCEPTANCE – A detailed proposal is presented to and accepted by the airline	INITIAL MAINTENANCE ANALYSIS. Based on a review of the airline's facilities and intended operation, a general maintenance plan can be provided, and a basic estimate of maintenance man hour requirements is made	INITIAL FACILITIES AND EQUIPMENT ANALYSIS. A preliminary general analysis of the airline's operation is made to identify maintenance equipment and facilities needed to support the 737. A ground support equipment investment forecast is prepared to help the airline determine its financial needs to introduce the airplane	SPARES INVESTMENT FORECAST. Boeing provides the airline with an accurate estimate of its spares requirements	TRAINING ESTIMATE. An estimate of the airline's maintenance and flight crew training requirements, responsive to its needs and desires, is provided
CONFIGURATION DEFINITION. A configuration discussion before contract negotiations is held between Boeing and the airline. At this time, the airline is made aware of the optional features available on the "737" and selects those it requires				
TERMS AND CONDITIONS. A draft contract is submitted for review				
PURCHASE AGREEMENT. In a meeting, prices and weights of the selected optional features are discussed and final selection is made. Contractual details are determined and the airline signs the contract for purchase (basic airplane plus options)				
MANUFACTURING DOCUMENTATION IS WRITTEN. The specifications of the 737 options plus those of the basic airplane are combined into one document that is identified by the airline's name. This specification is then issued inplant and becomes the controlling instrument for manufacture of the customized airplane. (See note.)	MAINTENANCE PLANNING CONFERENCE.–Boeing assists in planning the airline's maintenance operations program prior to its submittal to the airline's government regulatory agency for approval. A Boeing maintenance planning document is given to the airline for this planning. It contains Boeing recommendations on scheduling of airplane line maintenance, component, airframe, and structural inspections. In addition, check cards that outline the airline's 737 maintenance program are made available to the airline to further assist in establishing an acceptable maintenance plan	FACILITIES AND EQUIPMENT PLAN SUBMITTAL.–Boeing visits the airline and, after surveying its facilities, submits detailed study documents that identify all maintenance and service equipment required. In addition, Boeing assists the airline and the suppliers select maintenance/overhaul equipment and facilities	CUSTOMIZED INITIAL SPARES PROVISIONING.–Boeing develops a list of recommended spare parts to support the airline's 737 operation	

Note: An airline representative is assigned to monitor production of the airplane. He can be an employee of the airline or of Boeing. In either case he participates in all meetings and decisions and can follow the airplane throughout the manufacturing process. He has a free run of the factory area and other facilities at The Boeing Company.

During Manufacture

AIRPLANE PURCHASE, PRODUCTION, AND DELIVERY	MAINTENANCE AND OPERATIONS	FACILITIES AND EQUIPMENT	SPARES	TRAINING
DESIGN REVIEW Engineering drawings are revised against the specification document, approved, and released to Manufacturing. Parts are purchased and production starts	PLANNING VISITS Follow-on visits by Boeing personnel are made to assist the airline in refining its maintenance plan	FACILITIES PROCUREMENT The airline starts procurement of special facilities recommended in the facilities and equipment plan		MAINTENANCE TRAINING The airline's maintenance and operations personnel are trained at the Boeing ground school in Seattle and Renton, Washington. Airplane familiarization, airframe and systems, electrical systems and electronic systems are covered
		TOOL AND GROUND SUPPORT EQUIPMENT DRAWING AND DOCUMENT SUBMITTAL - When the facilities and equipment planning is completed, ground support equipment documents and special tool drawings are shipped to the airline	INITIAL SPARES PROCUREMENT If requested, Boeing procures and ships all initial spare parts SPARES TRAINING Airline personnel are thoroughly indoctrinated to Boeing spares documentation, oriented to provisioning and supply procedures, familiarized with 737 components and trained in spares selection techniques in the airline's facilities as well as in Seattle	
HARDWARE REVIEW A hardware review occurs at the last stages of final assembly to ensure that the optional features are correctly incorporated into the airplane		GROUND SUPPORT EQUIPMENT PROCUREMENT - Procurement of the service and ground support equipment recommended in the facilities and equipment plan begins		
	MAINTENANCE PLAN SUBMITTAL Assisted by Boeing, the airline's maintenance plan is submitted for approval by the government regulatory agency			FLIGHT CREW GROUND SCHOOL The on the ground portion of the training precedes airplane delivery. It includes classroom work, cockpit procedures, and simulator training
FINAL FLIGHT LINE CHECK When the airplane is on the flight line, a final check is made by the airline's representative to ensure that it is ready for delivery. This check covers mainly airplane markings, interior, seats, fabrics, colors, etc				

Delivery and Beyond

AIRPLANE PURCHASE, PRODUCTION, AND DELIVERY

DELIVERY The airplane is checked out by Boeing crews on the ground and in the air. Boeing's contract administration department notifies the airline as to when the airplane will be ready for acceptance flight and delivery to the customer.

MAINTENANCE AND OPERATIONS

MAINTENANCE SUPPORT–Follow-on visits are made by Boeing maintenance technicians to help improve the airline's maintenance efficiency. These technicians help the airline to establish maintenance efficiency and ensure a smooth, profitable introduction of the airplane. In addition, the airline is continually provided maintenance data, feedback about maintenance experiences of other airlines, as well as maintenance analyses that are useful in day-to-day operations.

OPERATIONS ENGINEER–Boeing operations engineers provide advice on operational performance problems and, if necessary, give personal on-site assistance to the airline's operations personnel. A Boeing operations engineer can train the airline's personnel in the use of performance charts, in monitoring of flight techniques, and in performing audits.

FIELD SERVICE ENGINEER–A Boeing field service engineer is assigned to the airline for as long as needed to assist the operator in gaining maximum benefit from the aircraft. He is in direct contact with the factory and available on both maintenance and operational matters.

FACILITIES AND EQUIPMENT

SPARES

'ROUND-THE-CLOCK ORDER SERVICE Expedite orders are on their way to the airline within 24 hours, and parts needed for a grounded airplane are shipped within 2½ hours of an AOG (aircraft on the ground) order. Routine orders for any parts in stock at Seattle are shipped within 15 days.

TRAINING

FLIGHT TRAINING The in-flight training program is conducted at or near Seattle, Washington, in the airline's 737. It starts immediately following airplane delivery and is completed within 30 days. Boeing provides normal maintenance during flight crew training on the airline's first 737 at no charge. The airline pays for fuel, oil, parts, landing fees, insurance, etc.

ROUTE PROVING AND LINE CHECKS–After the airplane is delivered and training is completed, Boeing can provide instructor crews for about 30 days to assist in line flying. These crews can ferry or assist in ferrying the aircraft from Seattle.

PROFICIENCY CHECKS–About 6 months after completion of line flying assistance, an instructor crew can, if requested, conduct 2 weeks of proficiency checks of flight crew personnel at the airline's facilities.

SECTION IV

FEASIBILITY STUDY

Task III of this study identifies those candidate commercial practices believed to be suitable for military use which were described in Section III. In addition, where feasible, the significant differences and cause factors for each practice are discussed along with the practicality of applying each commercial practice to military derivative programs.

The candidate commercial practices are presented for each of the major program phases discussed in Task I.

A. Candidate practices for the Initial Planning phase

1. Consider contractor assistance in the preparation and review of RFP's before issue. On a commercial program the RFP equivalent appears to benefit from constant interface and iteration until contract signature and go-ahead. This is also true for a military program up to and including formulation of the formal RFP. Through coordination with the various commands the RFP may have requirements added to the work statement, to the boiler plate and to the data requirements. Some of these requirements could include specifications, regulations and standards which impact the statement of work and hence the program cost without commensurate program benefit. When these requirements would result in impact to the commercial part of a derivative program, some of the cost may be avoided by using practices and data already developed for the commercial hardware. (Examples are provided in Section III and Section V.) A review of the final RFP before official release by interested contractors could point out areas where a specification or standard deletion, deviation or addition could more suitably tailor the requirements to the program before official release of the RFP. This review could also give the contractor more freedom to apply his unique skill and experience to the proposal elements and may result in a more responsible proposal and cost-effective product to meet the government requirement.

2. Establish increased emphasis on planning the program so as to achieve the benefit of program stability in funding, schedule, and work statement. In general, lower cost of derivative military program procurement as compared to pure military procurement is tied closely to achievement of program stability. It includes planning for the utilization of established technology, wherever possible, and planning for sufficient production to achieve learning curve benefits and to amortize non-recurring costs. Instability in any one of the three variables of funding, schedule and work statement generally results in replanning effort for major elements of the program. On a commercial program the technical effort may not require work statement changes as frequency as on military programs. However, military programs are uniquely susceptible to funding and hence program schedule instability. One undesirable consequence of funding/schedule instability can be the need to "open" and re-negotiate supplier contracts in an environment where

the buyer has substantially less leverage than when the subcontracts were initially negotiated. It may not be practical to implement long term program funding, but it is a key to program stability, steady progress and the elimination of the replanning cost driver which diverts resources away from those needed to obtain direct program results.

3. Further reduce data submittal volume and optimize data delivery timing. Commercial practice tends to minimize the volume of data needed by the customer and the government for visibility. Furthermore, the required data is carefully time-phased with the particular program work element phase. Replanning discussed above heavily impacts the generation and delivery of the data the military customer needs for visibility. Too much data may be required too early in the program before the program elements have stabilized. Data may also be required on the commercial elements of a derivative program which is significantly different than normally generated. At one time, when concurrency was part of the DoD procurement philosophy (Minuteman Program), it was expected that since "time" was the driving factor and lead time needed to be severely reduced, the additional cost for program, hardware and related data changes would be acceptable to the nation. Some of the planning practices and philosophy of that period may still impact the current philosophy of lower life cycle cost and require data before a specific program element has stabilized. On derivative programs careful initial planning could allow for program element stability and greater use of the commercially developed data.

B. Candidate Practices For Program Management

1. Consider the program involvement of fewer but more highly experienced people. Efforts to tailor the RFP requirements; to achieve stability in funding, schedule and work statement; to reduce data volume and timely data submittal to track the completion of the work task, all these efforts, in aggregate could permit some reduction in total program personnel. The system project office could consider assigning some key personnel experienced in aircraft engineering disciplines such as hydraulics, electrical, avionics, and structures, on-site, to make technical decisions. This parallels the commercial practice where the FAA actually delegates selected on-site contractor personnel within the program to certify that certain designs and tests meet FAA requirements and Federal Air Regulations.

2. Delegate more responsibility to the AFPR, particularly for routine and administrative items. The commercial practice of a small on-site group to make day-to-day decisions could shorten both the coordination time and data required. A summary status of decisions made could be communicated to the SPO rather than by correspondence and data packages of decisions to be made.

3. Limit flowdown of military program management and administration requirements and specifications on derivative programs. The commercial practice of using well-developed business systems across a wide range of products results in benefits from improved skill levels and the learning curve, and the integration of management reporting loops and record systems. Elements of these practices may be carried into military derivative programs with their existing benefit especially during RDT&E and the acquisition phases. Advance review of the RFP accompanied by careful initial planning can identify those military requirements and business system elements which are met by the existing commercial practices already applied on the commercial elements of a new derivative program. This could allow avoidance of some of the cost impact of changing or adding to existing commercial business systems and records to implement related military requirements.

4. Reduce change flow time. Commercial practices described in 1 through 3 above and implemented to some degree, could help in reducing change flow time. This might be especially true of a combination of items 1 and 2 where a deputy program manager and a small group of skilled technical personnel located with the AFPR could quickly make decisions with a minimum of data on a specified group or level of changes.

   Commercial practice indicates that significant reduction in change flow time greatly aids program stability and reduces out-of-sequence changes and their attendant higher cost.

C. Candidate Practices for Design Engineering

1. Consider shifting to greater use of "output" criteria validated by test rather than "input and control" criteria supplemented with "how to" requirements. The commercial elements of military derivative programs tend to be developed with relatively broad requirements and a minimum of detail requirements. This appears to be primarily because the commercial customer tends to rely more heavily on seller warranty than on the inclusion of the detail design requirements and the control and feedback requirements and data which provide the military customer with visibility. For example, the commercial ARINC 413 requirement for electrical equipment specifies voltage supplied at terminals. While equivalent military requirements do the same, they also may control other electrical characteristics (e.g., line drops), packaging, materials, parts, processes, testing, product assurance criteria and other valid, necessary requirements to control the development of new, high risk military hardware. However, on commercial equipment being adapted to military use, careful review can limit the application of "input," "control" and "how to" requirements. It can limit the data where the hardware and its historical record indicates the "output" requirements for the derivative application are being met.

2. Increase the extent of tailoring of design requirements to the program needs. In general, government and military requirements in specifications, standards and regulations do not appear to be a principle source of unnecessary cost for military procurements. They are important for the achievement of:

   a) Experience Retention and Dissemination
   b) Standardization of Hardware Equipments Across Programs
   c) Standardization of Processes for Commonality of Maintenance and Repair

Consolidation of specifications appears to be desirable in those areas wherein many specifications may exist to deal with part of a more general subject; such as, the separate standards and specifications on electromagnetic compatibility or in the product assurance areas of reliability and maintainability. The study resources did not lend themselves to a detail investigation of these areas. However, the study of the three derivative programs at the contractor shows a high degree of requirements specification "tailoring" to suit the needs of program. This tailoring is often in the form of deviations incorporated into the basic contract and/or in use or non-use of standard specifications. It is the concensus of questionnaire responders that it would be practical to accomplish even more tailoring to reduce costs, especially very early in the program, beginning with the RFP before program go-ahead and carrying on with the initial planning phase. The sooner the tailoring takes place the more life cycle cost avoidance is achieved.

Tailoring should be critically examined for all derivative program elements with the possible exception of mission peculiar equipment. Occasionally, the tailoring may appear to be . onsistent but there is usually good reason for it. For example, on one derivative program it was decided to change the commercial synthetic hydraulic fluid, which was previously selected for its relatively high resistance to fire, to MIL-H-5606 type fluid. This same change was not made on other derivative programs which still use the commercial fluid. This decision was justified on commonality of logistics (DoD-wide supply and lesser cost of mil oil) and maintenance (potential of contamination if commercial system were serviced with mil oil and cost of flushing and of changing seals in all components). and more than offset the following:

- Part number change for all hydraulic units impacting many drawings and specifications

- Special handling procedures and test facilities at both the contractor and supplier locations

- Increased part cost, since each part became one of a few instead of one of many from a commercial production line

- Increased the risk of mixing seals and sub-system contamination when airline industry support capability is used

- Added overhaul data, AGE, training, initial provisioning of overhaul parts and spares to the military pipeline

This example shows how important a specification deletion, or tailoring, can be to the life cycle cost of a derivative aircraft sub-system or equipment.

D. Candidate Practices for Manufacturing

1. Make maximum use of existing commercial fabrication and assembly, quality control, purchasing specifications, processes, records and data, hardware, tools and skilled personnel on derivative aircraft programs. The implementation of this practice begins with RFP review and initial planning where the tailoring of military requirements reduces the flow down to established contractor and supplier operations. Avoiding control type "input" and "how to" changes to established operations, when their output meets program requirements, permits continued commercial program stability and maximum use of built-in capability without the added costs of new records and data, and retraining personnel. When changes are required, a uniform application of these changes across the several programs of a large contractor would help hold down cost.

2. Strive for stability of manufacturing schedule and production quantities. Stability of schedule permits orderly procurement and flow of the program hardware into the end item and to the customer. Learning curve benefits continue to accrue as production proceeds. Larger production quantities allow program unit costs to benefit from the amortization of non-recurring cost.

E. Candidate practices for Testing

1. Integrate and use existing test procedures and data where possible. When it can be domonstrated that an existing equipment is being applied in essentially the same environment by mutual agreement between contractor and Air Force, existing data can be used to qualify the item by similarity. The Government-Industry Data Exchange Program (GIDEP) is an excellent source of part/component/

and material test data to aid this function. Need to know can be obtained from the Air Force to acquire AFM 66-1 field experience data on related equipment. This data can be processed to support reliability and maintainability analysis which may replace or reduce special R&M testing. Often testing costs for parts and components can be reduced by using existing test data on several required parameters and only testing the devices for the one or two parameters on which test data is not available. Test procedures for components and parts as well as test equipment calibration procedures are also contained in the GIDEP data banks.

2. Obtain data needed for demonstration of reliability and maintainability from the basic test program. Sometimes different types of tests can be combined to reduce cost. For example, some reliability and maintainability testing might be integrated within the subsystem acceptance test program at the supplier's facility and the higher level integration ground and flight test program at the prime contractor's facility. A few more operating hours may be required in some cases, but in total, as in commercial practice, cost can be reduced.

   Here again a tailoring and integration of the requirements in the test specifications, standards and regulations can promote improved integration in the planning of the overall test program. This should help in achieving confidence in meeting program requirements while holding down life cycle costs impacted by testing.

F. Candidate Practices for Operations and Support

1. Expand the application of airline maintenance practice (MSG-2) to all applicable programs. This technique for determining the essential scheduled maintenance requirements for new aircraft has been shown to be practical and effective for derivative programs. The practice is being incorporated in MIL-M-5906D.

2. Make increased use of contractor support capability. This support can include other on-base support functions as well as spare part provisioning. A key to the implementation could be a single contract with the aircraft prime contractor who, in turn, draws on the entire commercial aviation industry for support. Early experience on derivative programs indicate the sooner this decision is made, at RFP formulation or in the initial planning phase, the more effective are the trades that permit this practice to reduce life cycle costs.

   Relatively small derivative programs with equipment deployed around the world present a unique challenge. Here close working relationships with airline industry support capability on a reciprocal arrangement might help reduce life cycle costs in the Operations and Support area.

3. <u>Make increased use of commercial handbooks, training and spares provisioning practices</u>. When contractor support is contracted, this practice can be readily implemented. One of the stated reasons for rewriting commercial data and programs was to fit the different backgrounds and skill levels of military personnel. Early derivative experience seems to indicate that this does not appear to be a major problem.

SECTION V

IMPACT ANALYSIS

Task V consists of analyzing the available data, relating to the differences in military and commercial acquisition and support practices, in terms of cost, flow time and resources, and of evaluating the impact of commercial practices identified for application to military programs.

The following paragraphs present the life cycle costs of a typical program in which the commercial practices, modified commercial/military (derivative/contractor support) practices and normal military practices are compared. Calendar flow time comparisons and resources saving are also presented.

A. Life Cycle Costs

Following the introduction of the contract support concept by the Air Force in 1967, a number of studies were conducted by the contractor to determine the potential effect of this concept on several programs which could involve derivative aircraft. One of the principal studies involved the Advanced Airborne Command Post (E-4A) and its life cycle costs.

In the E-4A study, the acquisition costs considered three versions of the 747 airplane, all in a similar configuration:

1) As it is being produced commercially,
2) As it is produced as a derivative (E-4A), and
3) As it would be produced if the military specifications were required on the current commercial airplane.

At the time of the study, the acquisition cost of the command, control and communication (C^3) equipment was not available and consequently was, and is not, included. Since this cost would be the same for all versions, its omission is not considered to have a detrimental effect on the analysis of the airplane life cycle costs which is the objective of this part of the study.

The operations and support evaluation also did not include the C^3 equipment nor other constants such as crew pay, fuel and minor variables, such as base support. Three concepts of support were considered:

a) All Contractor Maintenance wherein the prime contractor would perform all on-base maintenance and repair while overhaul was accomplished through subcontracts with the airline industries at their facilities. Since airline maintenance personnel would probably be recruited to do the work, this concept is considered equal to airline maintenance.

b) Contractor Support where the Air Force personnel man the flight line and docks in a troubleshoot-remove and replace-inspection practice. The contractor would provide the spares and utilize the capability of the airlines to perform repair and overhaul functions at their facilities. This is very similar to the current E-4A procedure.

c) Normal Air Force Maintenance system of organizational, immediate and depot levels attendant with the AGE, spares, spare or overhaul parts and data.

The results of the study are shown in Figure 24. The combination of a commercial aircraft with airline maintenance is used as a relative life cycle cost factor of 1.0. The current derivative program is compared to that with a relative cost factor of 1.18 while the mil spec aircraft with normal Air Force support has a relative cost factor of 2.56.

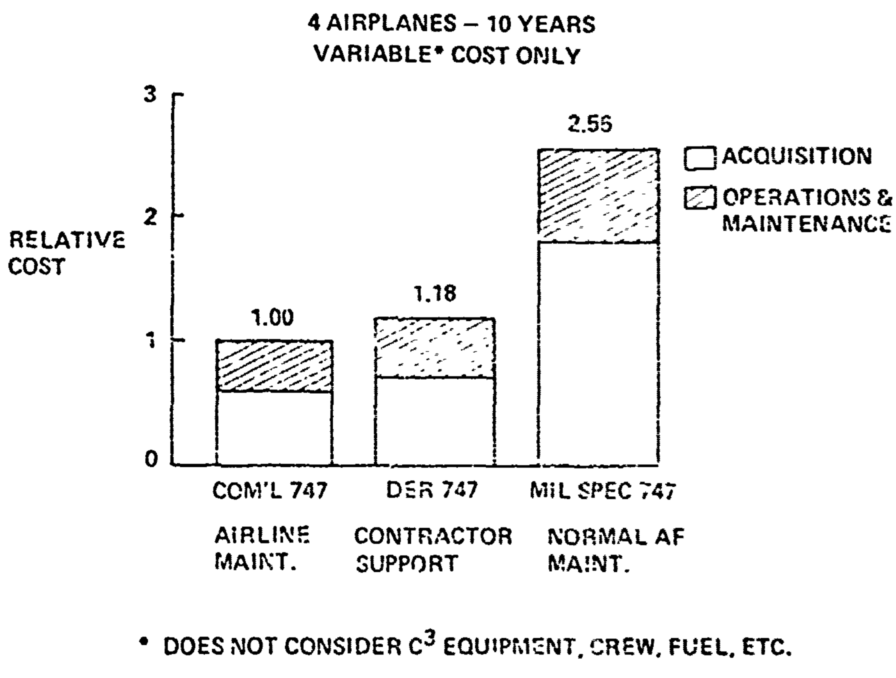


Figure 24. Life Cycle Costs - E-4A

Existing programs, other studies of various segments of the various maintenance concepts applied to such programs, and other data from contractor experience provide backup data to substantiate the E-4A study cost savings shown. These data are presented below and include (a) use of contractor support, (b) engine savings, (c) cumulative program costs, (d) flight test costs and (e) material costs.

The reduction in logistics costs on the T-43A is predicted to be similar to those of E-4A 747 study (utilizing contractor support). (See Figure 25.) After one and one-half years of operation, the portion based on contractor support is proving the prediction.

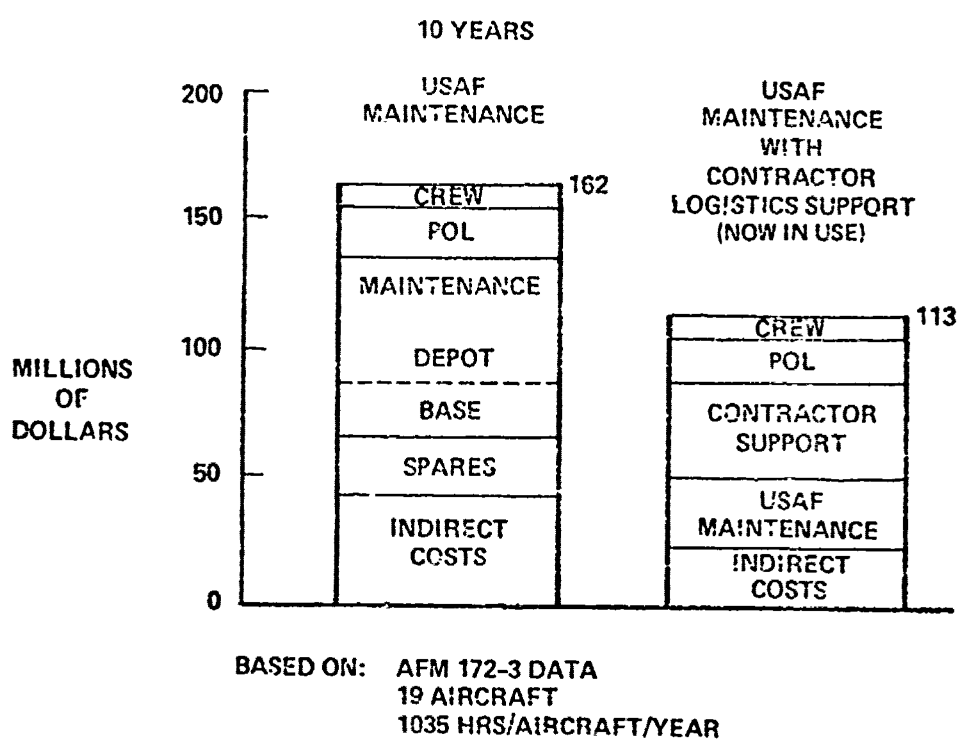


Figure 25. T-43A O&M Costs

Approximately 20% of the total program dollars over the first Aeromed contract support years was avoided initially because no funds were required for initial spares and for AGE for shop and depot use as the results of an AFLC study show in Figure 26. Additionally, the comparison shows the longer the contract is in effect, the more the government saves. Percentage-wise, the government saved 45% of a normal five-year support cost.

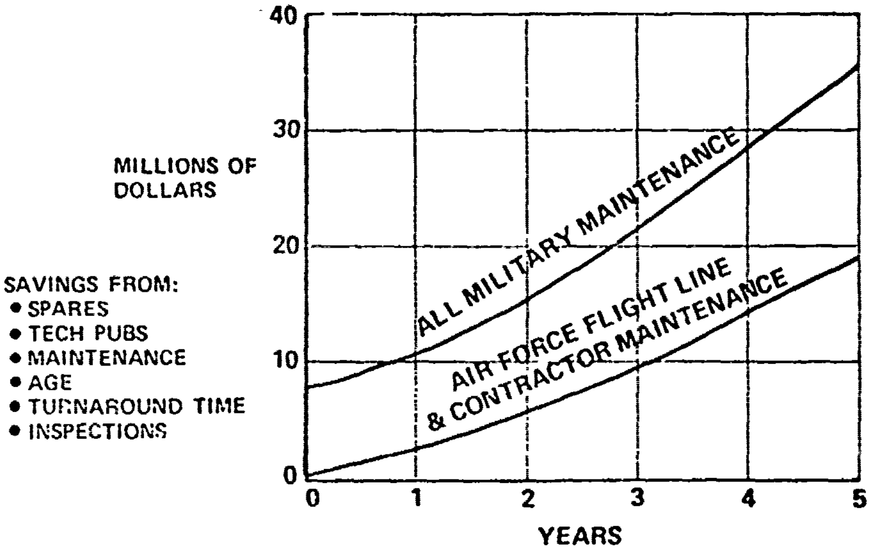


Figure 26. Aeromed Support Cost Comparison

The greatest potential of cost-saving in contractor logistics support is the provision of spares by the contractor during the early years of a program. Air Force and contractor statistics show that about 50% of initial spares become obsolete or are never used. Beside the obsolescence factor of parts, at least 50% of initial Federal Stock Number (FSN) expense could also be avoided. The supply system savings of contractor support also result from high volume of the commercial system and from a shorter pipeline. The 10-year savings estimated for the E-4A study were $84,910,000 for no FSN usage (per AFSCM/AFLCM 375-6, dated 20 May 1968) and $24,826,000 (49%) for supply.

Two studies were made on this cost saving obtainable from the supply system: on the potential use of the 747 as a tanker, and for the Utility Tactical Transport Aircraft System (UTTAS) helicopter.

The 1970 study of a potential 747 tanker program advanced the concept of utilizing contractor support until each of five bases had received their complement of ten aircraft then transferring the accountability of the spares at the time of delivery of the tenth aircraft (stocking one base at a time). When all aircraft were delivered, the depot capability was transferred to the Air Force. This method was compared to normal or all Air Force maintenance and COMBS (Contractor Operated Main Base Supply as now used on the E-4A). The results are shown in Figure 27.

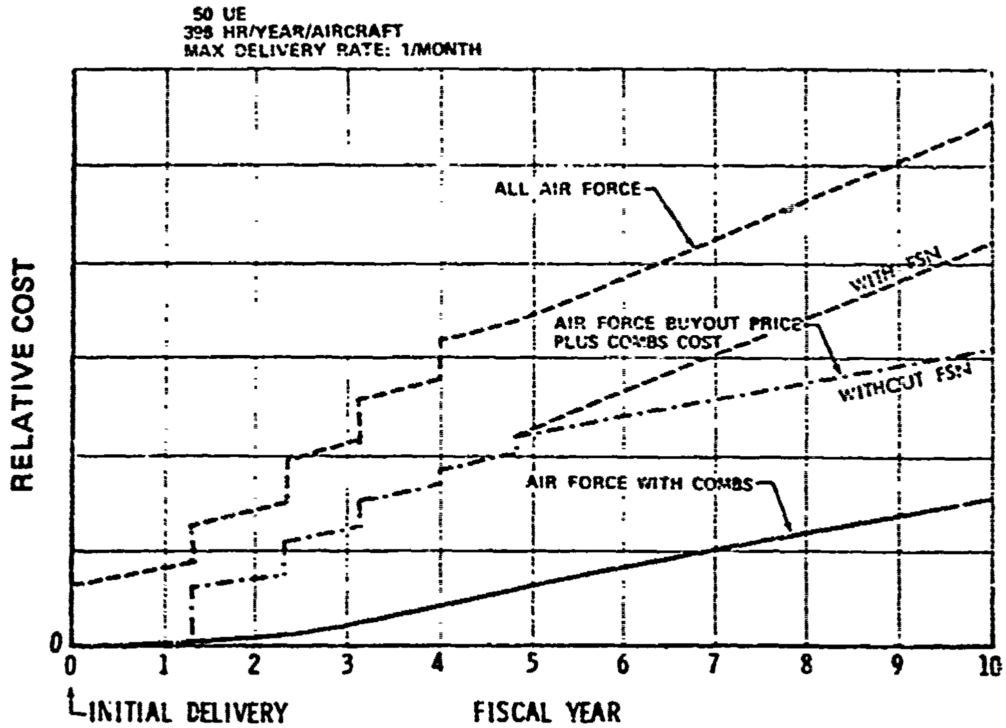


Figure 27. 747 Tanker Supply Costs

For the UTTAS program, the contractor discussed the potential use of a contractor supply system wherein the contractor would provide all spare and repair parts requirements during the prototype, test and evaluation phases. This would continue through the maturity phase and into the production program until the customer expressed a desire to transfer the support responsibility to his own conventional supply system. The proposal indicated about 40% savings (Figure 28).

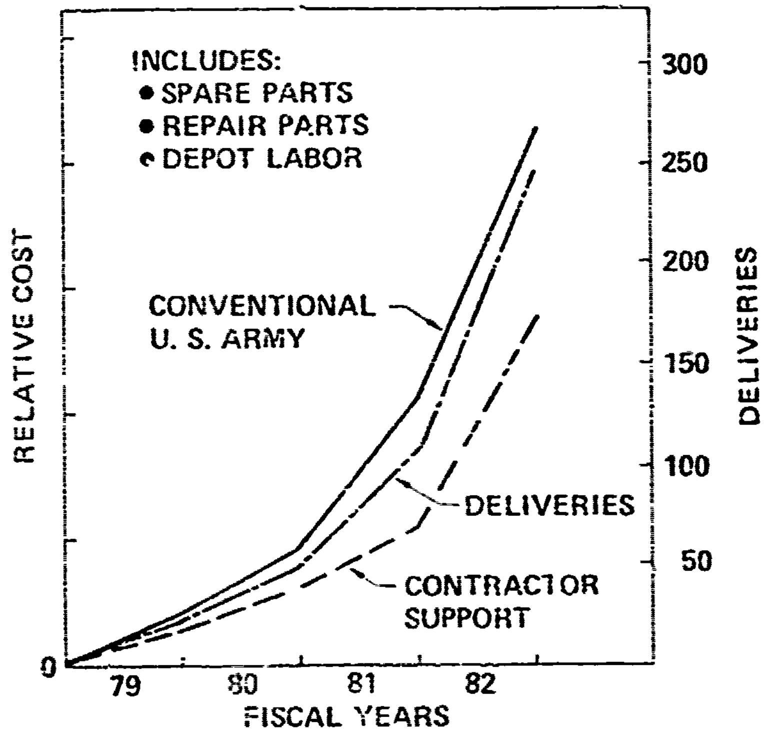


Figure 28. Spares Investment - UTTAS

The E-4A study also provides data on the savings to be realized on manuals, maintenance labor and AGE. Technical publications on a derivative program utilizing maintenance manuals in commercial format afford cost savings of $24,376,000 (78%), since use of commercial manuals permits the government to become one of many customers instead of a unique one and thereby able to enjoy a low unit price. The maintenance labor is reduced $8,388,000 (27%), because the greater numbers required under the military system more than offset the higher cost of civilian aircraft maintenance skills. The elimination of Aerospace Ground Equipment (AGE) from the shops and from the depot results in $2,965,000 (80%) savings in AGE costs.

The contractor's experience in maintaining government facilities points to the potential reduction of base support personnel costs by utilization of contractor support. The yearly cost of the average skill level within a support group now favors the contractor. Figure 29 shows current costs of an E-5, both within the Continental United States and overseas and a GS-6 civil service employee and compares them with contractor employee costs at Kennedy Space Center, Glasgow AFB, and overseas bases in England and Spain. A manning comparison is made for a transportation squadron. The reduction in personnel of 50% results from the deletion of military duties (20%) and to work improvement (25%-30%) due to less paid training, multiskill capability, personnel

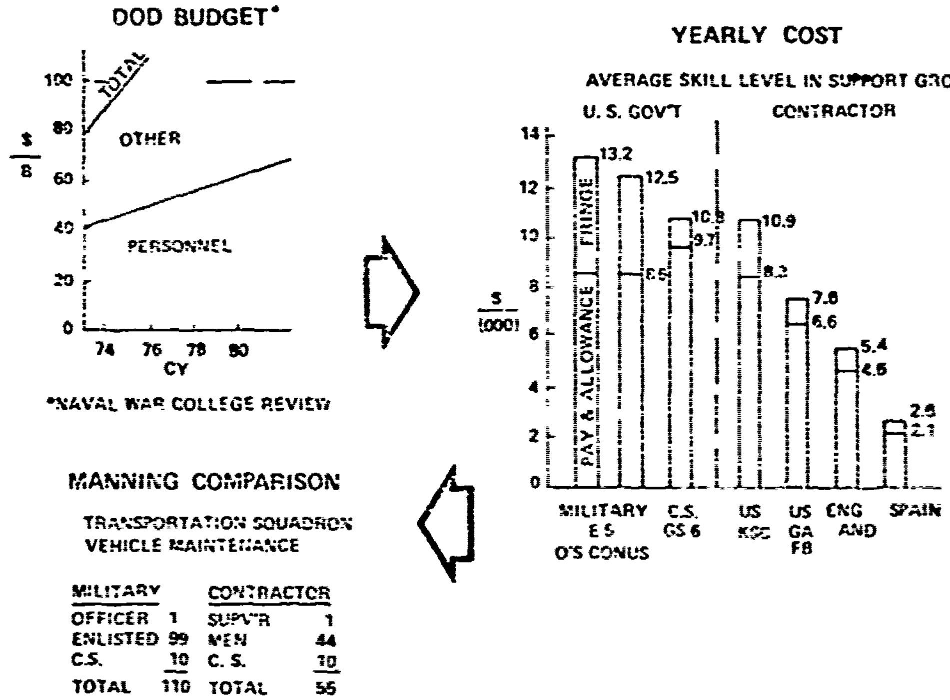


Figure 29. Contractor Support - Base Squadrons

longevity and profit motivation. This type of contractor support for base functions was studied for its potential use at a missile base and at a transport aircraft base. The savings per year in personnel costs were $11,000,000 at the missile base and $10,000,000 at the aircraft base.

The T-43A logistics support program included a special feature which is resulting in a great savings to the Air Force. Instead of using the traditional jet engine philosophy of hot section inspection and overhaul, an engine IRAN type program called Engine Heavy Maintenance (EHM) was included and accepted in the Contractor Support Package. Not only will there be a monetary savings to the Air Force, as shown in Table 14, but the 19-aircraft fleet is being supported with only four spare engines. Traditionally, the spare engine ratio has been one for every four installed.

TABLE 14. ENGINE SCHEDULED MAINTENANCE

Customer	Element	Interval
C-9A (Standard military)	Hot section inspection	2000 EH
	Overhaul	5000 EH
T-43A (Typical commercial)	Engine heavy maintenance	8000 EH
T-43A Savings: (per 8000 EH cycle)	76 Engine changes $7,486,090	

Another commercial airline practice, called engine derating, has been approved for use on the T-43A program to reduce failures and removals. This practice allows a reduction in take-off thrust on occasions when conditions of weight, temperature and runway length permit. (The reduction in peak engine temperature improves engine life.) Approximately 50% of all airline departures are now at reduced thrust. The summary of these benefits is shown in Table 15.

TABLE 15. ENGINE DERATING

Procedure: Reduce takeoff thrust 5%

Result:	% Down
Premature removal rate	50
Inflight shutdown rate	39
Fuel expenditure	5
Engine maintenance material	20
Engine overhaul labor	2

One research effort by the contractor for an effective analytical model to determine costs of a commercial aircraft program with many variables began with the basic elements of number of customers, schedule and quantity of design changes. The results of one initial study show the difference between the cost of a typical commercial aircraft program with many customers, tight schedules and many changes and the cost of an ideal program with a single customer, optimum schedule, half the normal changes and a design with fewer part numbers (Figure 30). While these cases are hypothetical examples for illustrative purposes, there is nothing imaginary about the cost differences. The factors moving these costs have no relation to product quality or performance objectives. The conclusions from these data are that stability of planning of the <u>total</u> program is the key to cost effectiveness and the program manager <u>must</u> have the experience, authority, and resources to make the proper trades for life cycle cost early in the preliminary design phase.

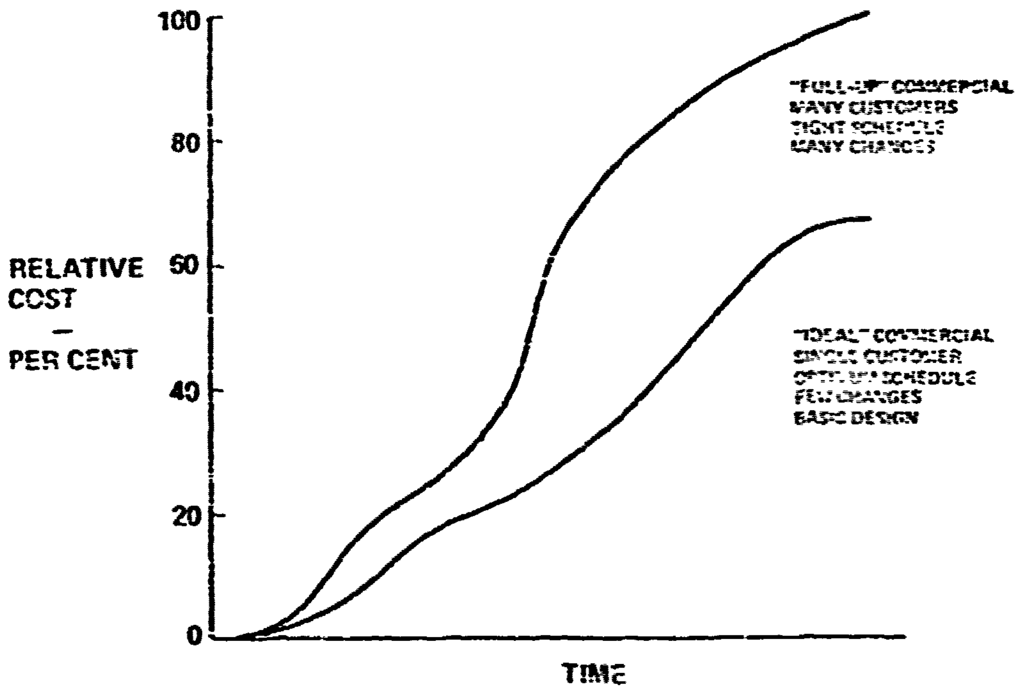
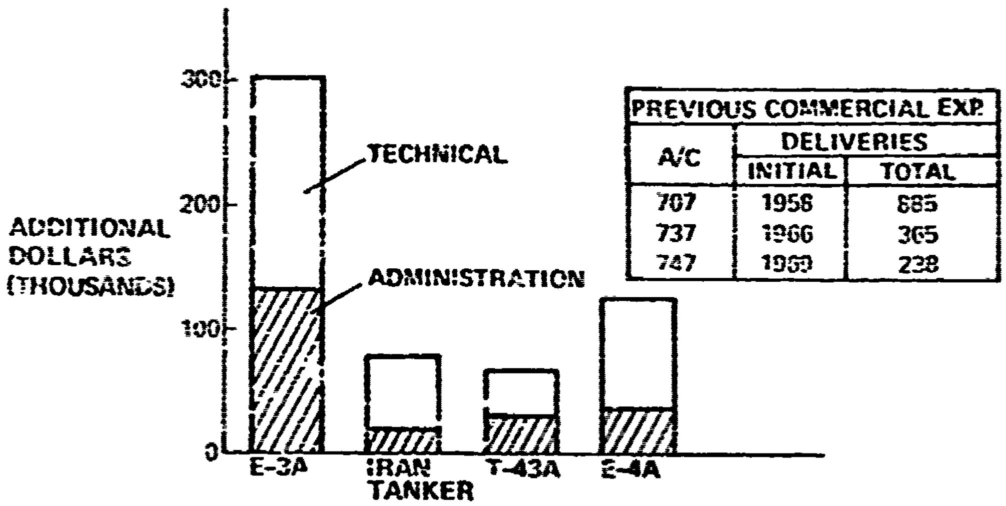


Figure 30. Cumulative Program Costs

The cost of complying with AFR 55-22, "Contractor's Flight Operations," is shown in Figure 31. None of the requirements listed in this regulation is judged to add to the safety or efficiency with which a flight test program is conducted by the contractor on derivative aircraft since the contractor is flying the same basic aircraft every day.



$583,530 Additional cost on four contracts as of October 1974

- Egress training
- Physiologial training
- Flight physicals
- AFCMD form 24
- Flight equipment

Figure 31. Flight Test Costs - AFR 55-22

Part procurement is another area for potential cost avoidance. The cost increases, percentage-wise, in the prices of parts of military programs are estimated to be:

(a) 5 to 10%, due to small quantities
(b) 50 to 100% when "Hi-Rel" parts control is required
(c) 15% or more due to special testing and verification requirements.

The portion of the cost of a commercial part due to a warranty program is 2%-5%; however, this is spread over a greater production quantity, with the seller's knowledge that he will sell spares at a figure higher than the production unit price, which is considered as a manufacturer's discount. (Common practice in commercial field, but not allowable by the government.)

The research into AFSCR/AFLCR 66-24, "Maintenance of Aerospace Vehicles and Related Support Equipment," consumed 1500 manhours to evaluate all the data contained or referenced therein. One of the sub-tier publications, MIL-STD-1518, Fuel Handling, would require special fuel handling capabilities over and above commercial practices. Compliance with this standard would have resulted in the expenditure of $500,000 for facility changes.

B. Program Calendar Flowtime

The following paragraphs comment on calendar flowtime differences between military and commercial practices which could be identified from the available data. The length of a program depends on many variables and flow caused by each is dependent upon the circumstances existing at the time of program inception. Emergencies, controversy, competition and budgets will shorten or lengthen the conceptual and validation phases of both military and commercial aircraft programs. The flowtime for the design and fabrication phases of both military and commercial programs is essentially the same for equivalent aircraft. Unless serious design problems appear during testing, the time from rollout to first flight is essentially the same. This data is shown for contractor aircraft in Table 16. Based on one study of an "ideal" new commercial aircraft, where preliminary design studies and wind tunnel testing are considered continuing research efforts from the time of the last production aircraft, the product definition phase would begin fifteen months before go-ahead, the detail design and fabrication would take 30 months to rollout with first flight three months later. The flight test program to certification would be less than one year.

TABLE 16. AIRPLANE PROGRAM FLOWTIMES
MONTHS

Model	Go-ahead to rollout	Rollout to first flt	First flt to delivery or certification
B-47	—	3	13
B-52	—	5	10
367-80	22	2	—
707	25	1	10
720	—	1	7
727	27	3	10
737	24	2	8
747	35	5	10

The major variance between military and commercial program flowtimes is in the flight test phase, other things being equal. Up to one-third less flowtime for the commercial program is typical. As discussed in Section III, causes for the difference appears to be in flight crew rest periods and a somewhat more inflexibility in test change approval. The flowtimes for the comparison of military and commercial versions of the 737 are shown in Figures 32 and 33.

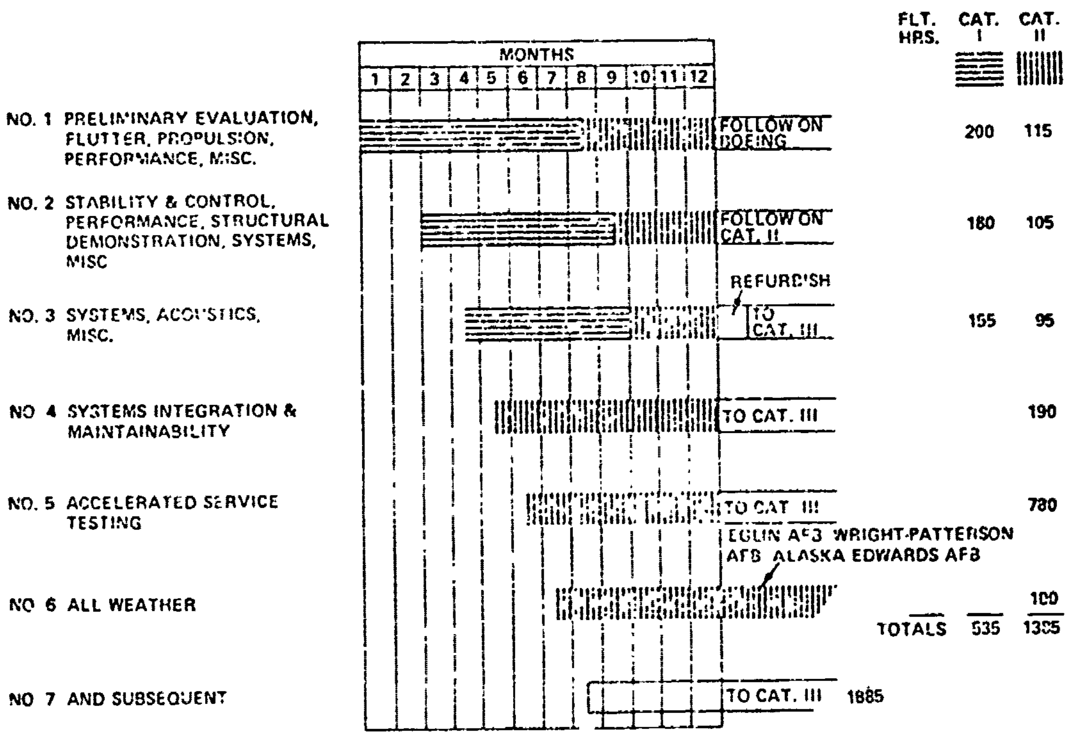


Figure 32. 737-100 Military Test Program

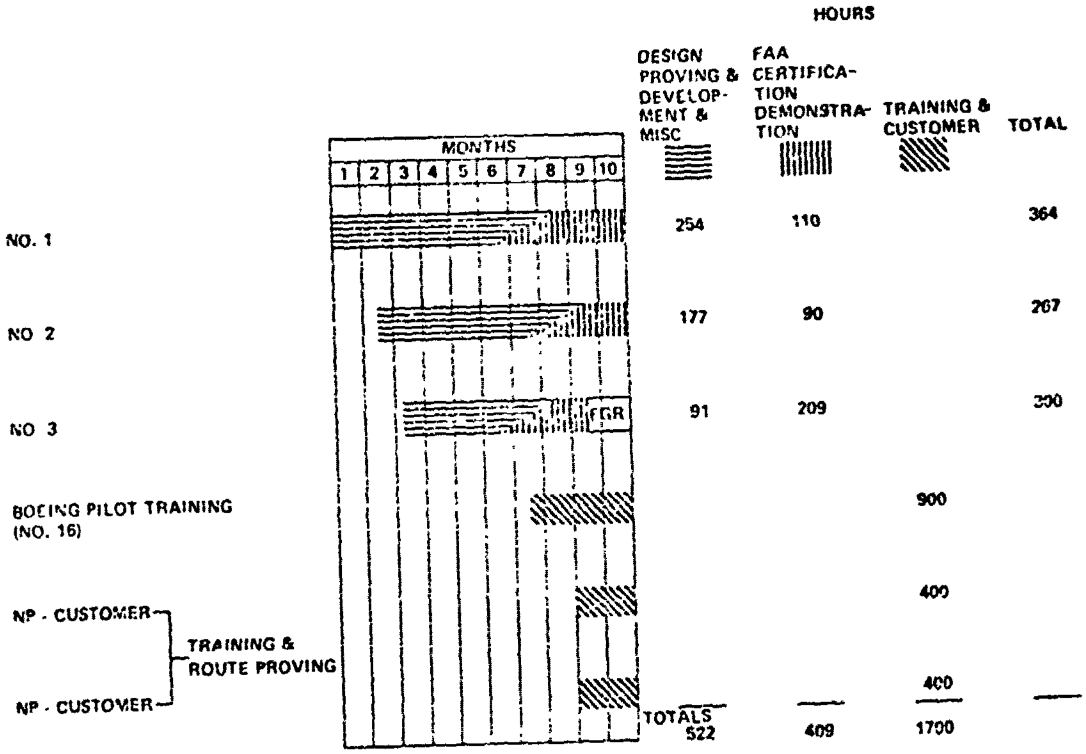


Figure 33. 737-100 Commercial Test Program

C. RESOURCES

The following paragraphs comment on those savings in resources between military and commercial practices which could be identified from the data analyzed.

Finance managers indicated a requirement for three times the number of estimators on military programs to comply with DoDI 7000.2 than are on commercial programs. Some project engineers on derivative programs indicated that 6% of their manpower budget goes to monitoring contract changes. On one derivative program with minimum derivation (Peace Station), one engineer handled the administrative job on a part time basis and had less than a file drawer of data. The T-43A program with a larger integration job had four personnel including a supervisor, a large office and many files and bookcases. The ratio in number of personnel required to respond to a typical equivalent military and commercial RFP is estimated to be approximately six to one.

The non-recurring portion of life cycle costs (RDT&E) is essentially the same on both military and commercial programs, 60-80 of total RDT&E costs, according to available data. The production labor on a commercial program will run less than 50' of the cost. Estimated data for a similar military program shows labor to be 55-75 of the cost. The Operations and Support (O&S) personnel portion of life cycle costs of the E-4A study, where the on-base maintenance personnel went from 239 for all Air Force to 199 for contractor support to 107 for airline type maintenance, is an example of resource reduction.

D. SUMMARY

It was difficult to pinpoint savings, based on the data available for the study, in such a manner that the cost differences in each practice for each major program phase could be carefully quantified and validated. Some of the findings, when viewed from the standpoint of cost savings, were relatively insignificant (0.1') when compared to total program cost. Many of the findings involve a series relationship in that for a program life cycle cost saving to be realized, the chain of elements leading to this saving must remain intact from program inception to phase out. However, in aggregate the findings appear to point out areas of potential cost avoidance and therefore, were included in the study.

SECTION VI

RECOMMENDATIONS

A. GENERAL

This section of the report presents recommendations resulting from this study. These recommendations are grouped by program function.

B. INITIAL PLANNING

1. Review the Request For Proposal (RFP) to limit data requirements to "need-to-know" type only.

2. Eliminate "how-to-do-it" specifications, e.g., soldering process, from the RFP requirements on major aircraft contractors.

3. Reduce the data submittal volume and optimize data delivery timing.

4. Revise acquisition practices to permit free exchange between contractor and SPO without jeopardizing contractor's competitive position as is done on all commercial programs and as was done on the E-3A avionics competition.

5. Request contractor review of each RFP before its formal release to improve design and cost predictions. Pay him or consider it part of his response.

6. Continue to move toward lower technical cost (design-to-cost).

7. Strive to achieve the benefit of program stability in funding, schedule and work statement.

C. PROGRAM MANAGEMENT

1. Reduce data requirements by reducing the number of data specifications or waiving the parts of other type specifications which require data submittal.

2. Consider locating some key SPO personnel with the contractor to promote improved coordination.

3. As an alternate to No. 1, consider delegating more decision responsibilities to the Air Force Plant Representative's Office.

4. Implement derivative program management and administrative requirements by beginning with the contractor's specifications and Federal Air Regulations (FARs), then limit the application and flowdown of additional military requirements to areas of genuine need.

5. Implement the FAA DER/DMIR type practice on a military aircraft program.

6. Reduce change flow time by implementing recommendations 2 (or 3), 4 and 5.

D. DESIGN ENGINEERING

1. Specify output criteria and requirements rather than "input and control" requirements and "how to" solutions as much as possible Use commercial specifications and/or Federal Air Regulations when available and suitable.

2. Increase the tailoring of design and product assurance requirements to fit program needs.

3. Review the genuine need for specifications recognizing that stringent compliance can be as costly as justifying a deviation, e.g., the transient voltages defined by MIL-STD-704. Require compliance by specification and paragraph number, not by specification, only, or include the specific requirement as part of the system requirements without reference to a specification.

E. MANUFACTURING

1. Make maximum use of the contractor's process and materials specifications, records and data, tools and skilled personnel on derivative programs where investigation shows they are adequate.

2. Minimize requirements for the use of military specification aircraft components on derivative aircraft unless they are required to be different/better than equivalent components currently used in commercial aircraft programs.

5. Consider deleting the requirement for AFSCR/AFLCR 66-24, "Maintenance of Aerospace Vehicles and Related Support Equipment," on derivative programs.

6. Strive to reduce out-of-sequence work by improved flowtime on changes required for the program.

F. TESTING

1. Review Categories I, II and III flight test requirements on derivative programs relative to existing commercial (FAR) test procedures to use existing contractor procedures or form new integrated test and evaluation procedures. This would permit tailoring requirements to each program and allow maximum use of existing test procedures and data.

2. Delete the requirement for AFR 55-22, "Contractor's Flight Operations," on derivative programs.

3. Delegate flight test personnel change authority to on-duty personnel.

4. Delete requirements for testing by utilizing data from previous tests or similar tests, particularly on derivative programs. The Government-Industry Data Exchange Program (GIDEP) can provide useful data.

5. Delete requirement for 24-hour flight crew rest for both military and contractor crews on derivative aircraft flight test programs.

6. Obtain data needed for demonstration of reliability and maintainability from the basic test program; i.e., do not contractually specify separate/independent reliability and maintainability tests and/or demonstrations.

G. <u>OPERATIONS AND SUPPORT</u>

1. Expand the application of airline maintenance practice as described in the "Airline Manufacturer Maintenance Program Planning Document, MSG-2."

2. Devise contracting techniques which will allow the Air Force to take advantage of industrial support capability when such support is cost-effective.

3. Use contractor support on all programs where cost-effective.

4. Consider joining airline consortiums and pools as appropriate to obtain world-wide spares support at minimum investment.

5. Make increased use of commercial publications, training and spares provisioning practices and products where appropriate. Add military requirements only on selected unique equipment and/or where the commercial data is determined to be inadequate to satisfy system requirements.

6. Evaluate the <u>true total</u> cost of competitive procurement of replenishment spares for real "savings" generated, and limit this practice to cost-effective procurements.

7. Explore the use of alternate/advanced data systems for operations and maintenance manuals.

8. Delay the requirement for manual and training data until after CDR.

9. Develop a flight-line/overhaul maintenance manual specification relative to the use of ATA commercial manuals in military programs. Review should be made of the T-43A, VC-137C, E-4A and other military programs where commercial ATA 100 organization maintenance and overhaul technical manuals are being currently employed. (These are usually supplemented by military unique T.O.'s such as the flight, inspection or other military oriented non-available commercial manuals.) The current technical manual specification MIL-M-7298C is inadequate for this application.

APPENDIX A

INDEX OF SPECIFICATIONS

1.0 General - Papers/Articles *

A-1 "Integrated Systems Test and Evaluation Program (IN-STEP) Concept." Compares development test-programs for military and commercial transport airplanes. Rough draft copy. May 1972.

A-2 "Design-to-Cost, Commercial Practices Vs. Dept. of Defense Practice." By J. Fred Bucy, Texas Instrument Corp.. Report of the Defense Science Board Task Force on Reducing Costs of Defense Systems Acquisition. ODDR&E, March 15, 1973.

A-3 6-7926-148 "737 Military Derivatives Program, Test Program Comparison," by D. M. Longton and G. J. Baron, New Business Support Unit, Flight Test Engineering, Oct. 17, 1966.

A-4 "A Quantitative Examination of Cost-Quantity Relationships, Competition During Reprocurement, and Military Versus Commercial Prices for Three Types of Vehicles," by M. Zusman. et al, Institute for Defense Analysis (IDA Study S-429), March 1974.

A-5 "Design-to-Cost, for Defense, Not Just a Buzz Word," by Lt. Gen. R. E. Coffin, Deputy Director, Defense Research and Engineering (for Acquisition Management), Dec. 1973.

"New Ways to Spell 'Contract Mismanagement,' Industry Overhead and Subcontracts," by Maj. Gen. D. G. Nunn, A. F. Contract Management Division Commander, Dec. 1973.

"Tough, Economy Minded Efficiency," by A. F. Chief of Staff George Brown, Dec. 1973.

A-6 "Criteria for Evaluating Weapon System Reliability, Availability and Cost," Task 73-11, Logistics Management Institute, March 1974.

A-7 "Design to a Cost: A Sampling of Extent of Implementation," by R. L. Bidwell, Defense Product Engineering Services Office, OASD (I&L), April 1974.

A-8 "Introduction to Military Program Management," Task 69-28, Logistics Management Institute, March 1971.

A-9 "Cost Versus Time," paper dated July 1969.

A-10 Boeing Corporate Policy #1C1 - "Planning and Control of Major Programs," dated Dec. 17, 1968.

* Although this report is based on Boeing experience, a number of papers by others are of interest relative to evaluation of commercial versus military practice. The following index includes both Boeing and non-Boeing material for reference.

1.0 General - Papers/Articles

(continued)

A-11	Planned Technical and Program Documentation Completed at Program Go/Ahead (Exclusive of Joint Venture Agreement), no date.
A-12	Coordination Sheet 71610-74-40, "Cost of Ownership, KC-135 Propulsion System," dated June 11, 1974.
A-13	B-1 Avionics Requirements, pages from SS07878139A0100, dated May 31, 1972. Lists government documents and North American Rockwell Corporation specifications for the B-1 Bomber.
A-14	B-1 Flow Chart - includes system definition, design discipline, interface, software and through integration test, dated 5-30-74.
A-15	BCAC Policy 6-1000-040, Product Technical Definition, dated August 30, 1968.
A-16	Defense Management Journal - Design-to-Cost, Special Issue September 1974.
A-17	MSG-2, Airline/Manufacturer Maintenance Program Planning Document.
LC-30	"Cost-Estimating Relationships for Aircraft Airframes," by G. S. Levenson and S. M. Barro, Rand Corp. (RM-4845-PR). Covers engineering, manufacturing, and flight test cost elements of airframe 'flyaway costs.'
RM-4049-PR	"Trends in Aircraft Maintenance Requirements," by W. H. McGlothlin and T. S. Donaldson, Rand Corp., June 1964.
Y-2244	"Design to Cost Application in Military Environment Means Changing Old Ways," by M. F. Wilson, Collins Radio Co., June 1973.
Y-2269	"Acquisition Objective Changes from One of Sophistication to Reliability at Lower Cost," by J. S. Gansler, Assistant Director (Electronics) ODDR&E, June 1973.
Y-2270	"Design to Cost: Concept and Application," by Cdr. F. H. Hollister, USN and R. R. Shorey, Office of the Assistant Director (Electronics) ODDR&E, July 1973.

1.0 General - Papers/Articles
(continued)

Y-2277	"Designing to Low Ownership Cost Requires Knowledge of Many Factors," by E. F. Durbin, Manager, Systems Planning and Economics Division - Technology Service Corporation, July 1973.
Y-2278	"Rationale of a New Maintenance Concept," by B. H. Colmery, Naval Air Systems Command, Fall 1973. On-condition maintenance and condition monitoring.
Y-2279	"IMPACT of Workload Variability on Repair Depot Operations," by M. K. Kennedy and R. L. Howard, Ogden Materiel Area, Fall 1973.
Y-2280	"Discourse on Comparisons between Commercial and Military Aircraft Logistics," by J. F. McDonald, The Flying Tiger Line, Fall 1973.
Y-2282	"A Procedure for Allocating Maintenance Downtime," by William Tinney, Xerox Corp., Fall 1973.
Y-2283	"The Air Force/Boeing Advanced Medium STOL Transport Prototype," by J. J. Foody, Boeing Aerospace Co., April 1973. Design to cost and commercial potential covered for STOL transport.

2.0 Document File

D-15441	Detail Spec. Tanker Transport - Model KC-135A.
D6-5152	Flight Operations Procedures required per AFP 55 22.
D6-17375	Detail Spec. Model 737-222 (United Air Lines).
D6-20115	Comparison of Military and Civil Flight Test Requirements.
D6-25444	Engineering Management Study.
D6-32420	Convertible Cargo/Passenger Airplane, Standard Detail Spec (737-200C).
D6-33510	Boeing Implementation of AFSC/AFLC Regulation 80-14
D6-40046-7	Economics Analysis - NASA Advanced Transport Technology Program: Design Trades. (Boeing 767-614.)
D6-40895-1	Delay and Cancellation Cost Analysis Technique.
D6-40949	Boeing 727 Maintenance Cost Development Summary.
D6-41708	Flight Operations Procedures.
D6-41863	Product Assurance Plan 727-300/200B.
D6-53505TN	Flight Test Requirements Comparison Study - Commercial 747 Versus Military Derivative 747M.
D6-53512	FAA Certification of Boeing Commercial Aircraft.
D162-10029-1	Summary of Air Force/Boeing Test Program Management Practices.
D162-10031-1TN	Military and Commercial Reliability Data Evaluation.
D162-10068-2	AMST Prototype Management Approach.
D162-10090-1-50	Commercial Airplane Experience.
D162-10172-1TN	Development Test Program Options - Tactical Transport Type Aircraft.
D162-10479-1	Adaptation of 747 Specific Behavioral Objectives (SBO) Program to Military Use.
No Number	KC-135 Program (History).
D301-10265-1,-2	Optimization of Reliability Test Hours for [illegible] During Engineering Development, Volumes I and II.

3.0 Commercial Publications

FAA/ATA Publications

ATA Spec. No. 100	Specification for Manufacturer's Technical Data.
FAR Vol. III Part 25	Airworthiness Standards: Transport Category Airplanes.
FAR Vol. VII Part 121	Certifications and Operations: Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft

ARINC Publications

Report #304	Electronic Installation, Guidance Material.
Report #306	Aircraft Electronic Installation, Guidance for Designers.
Report #403	Airborne Electronic Equipment, Guidance for Designers.
Spec. #404	Air Transport Equipment Cases and Racking.
Report #406	Airborne Electronic Equipment Standardized Interconnections and Index Pin Codes.
Spec. #408	Air Transport Indicator Cases and Mounting.
Report #417	Air Transport Automatic Flight Control System, Design Guidance.
Spec. #413	Aircraft Electrical Power Utilization and Transient Protection.
Report #414	General Guidance for Equipment and Installation Designers.

4.0 Military Publications

(Selected from Boeing Programs)

AFR 800-2	Program Management - Acquisition Management.
AFR 800-11	Life Cycle Costing (LCC).
AFLCP/AFSCP 800-19	Joint Design-to-Cost Guide.
DoD Directive 5000.1	Acquisition of Major Defense System.
MIL-STD-143B	Standards and Specifications, Order of Precedence For the Selection of.
MIL-STD-483	Configuration Management Practices.
MIL-STD-499A	Engineering Management.
MIL-STD-847A	Format Requirements for Scientific and Technical Reports prepared by or for the Dept. of Defense.
MIL-HDBK-127	Reliability Stress and Failure Rate Data for Electronic Equipment.
MIL-STD-781	Reliability Tests: Exponential Distribution.
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production.
MIL-A-8866	Airplane Strength and Rigidity -- Reliability Requirements, Repeated Loads, and Fatigue.
AFR 80-5	Reliability and Maintainability Programs for System, Subsystem, Equipment and Munitions - R&D.
AFSC/AFLC Reg. 66-24	Maintenance of Aerospace Vehicles and Related Support Equipment.
DH 1-9	Maintainability.
MIL-HDBK-472	Maintainability Prediction.
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipments).
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation.
DH 1-6	System Safety.
MIL-STD-882	System Safety Program for Systems and Associated Subsystems and Equipment.

4.0 Military Publications
(continued)

DH 1-3	Personnel Subsystems.
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities.
MIL-D-26239	Data, Qualitative and Quantitative Personnel Requirements Information.
MIL-V-38352	Value Engineering Program Requirements.
DH 1-1	General Index and Reference.
MIL-F-8785	Flying Qualities of Piloted Airplanes.
DH 1-2	General Design Factors.
DH 1-X	Checklist of General Design Criteria
DH 2-7	System Survivability (Classified).
DH 2-8	Life Support.
DH 2-1	Airframe.
MIL-A-8860	Airplane Strength and Rigidity, General Specification for.
MIL-A-8861	Airplane Strength and Rigidity, Flight Loads.
MIL-C-8073	Core Material, Plastic Honeycomb, Laminated Glass Fabric Base, for Aircraft Structural Applications.
MIL-R-7705	Radomes, General Specification for.
MIL-C-5462	Cover; Wing and Tail, Aircraft, General Specification for.
MIL-S-8806	Sound Pressure Levels in Aircraft, General Specification for.
MIL-A-9094	Arrester, Lightning, General Specification for Design of.
MIL-D-9129	Dischargers, Aircraft Electrostatic, General Specification for.
DH 2-2	Crew Stations and Passenger Accommodations.
MIL-STD-203	Aircrew Station Controls and Display Fixed Wing Aircraft.
MIL-STD-1333	Aircrew Station Geometry for Military Aircraft.

4.0 Military Publications
(continued)

MIL-K-25049	Knobs, Control, Equipment, Aircraft.
MIL-STD-850	Aircrew Station Vision Requirements for Military Aircraft.
MIL-W-7233	Windshield Wiper System, Electric, Aircraft General Requirements for.
MIL-R-83055	Rain Repellent Dispensing Systems Aircraft Windshield, General Specification for.
MIL-STD-1511	Inflight Emergency Escape System, Aircraft, Requirements for.
MIL-S-9479	Seat System: Upward Ejection, Aircraft, General Specification for.
MIL-S-18471	System, Aircrew Automated Escape, Ejection Seat Type, General Specification for.
MIL-S-83249	Slide, Escape, Aircraft, Inflatable, General Specification for.
MIL-S-81018	Survival Kit Container, Aircraft Seat, with Oxygen, General Specification for.
MIL-S-81040	Survival Kit Container, Aircraft Seat, Without Oxygen, General Specification for.
MIL-C-25913	Cartridge Actuated Devices, Aircraft Crew Emergency Escape, General Specification for.
MIL-S-38039	Systems, Illuminated, Warning, Caution and Advisory, General Specification for.
MIL-G-83063	Galley, Aircraft, General Requirements for.
MIL-A-8862	Airplane Strength and Rigidity, Landplane Landing and Ground Handling Loads.
MIL-L-8552	Landing Gear, Aircraft Shock Absorber (Air-Oil Type).
MIL-S-8812	Steering System; Aircraft, General Requirements for.
MIL-W-5013	Wheel and Brake Assemblies, Aircraft.
MIL-B-8584	Brake Systems, Wheel, Aircraft, Design of.
MIL-B-8075	Brake Control Systems, Anti-Skid, Aircraft Wheels, General Specification for.
MIL-A-8591	Airborne Scores and Associated Suspension Equipment; General Design Criteria for.

4.0 Military Publications
(continued)

DH 2-3	Propulsion and Power.
MIL-STD-1534	Engines, Aircraft, Gas Turbine, Technical Design Requirements.
MIL-E-5007	Engines, Aircraft, Turbojet and Turbofan, General Specification for.
MIL-S-38399	Starter, Pneumatic, Aircraft Engine, General Specification for.
MIL-S-27266	Starter, Engine, Cartridge and Pneumatic Shaft Drive, General Specification for.
MIL-P-8686	Power Units; Aircraft Auxiliary, Gas-Turbine-Type, General Specification for.
MIL-D-7602	Drive, Turbine, Air, Aircraft Accessory, General Specification for.
MIL-G-6641	Gearbox, Aircraft Accessory Drive, General Specification for.
MIL-D-27729	Detecting Systems; Flame and Smoke, Aircraft and Aerospace Vehicle, General Performance, Installation and Test of.
MIL-F-7872	Fire and Overheat Warning Systems, Continuous, Aircraft: Test and Installation of.
MIL-C-8188	Corrosion Preventive Oil, Gas Turbine Engine, Aircraft Synthetic Base.
MIL-F-38363	Fuel System, Aircraft, General Specification for.
MIL-F-8615	Fuel System Components; General Specification for.
MIL-T-18847	Tank, Fuel, Aircraft, Auxiliary External, Design and Installation of.
MIL-F-9490	Flight Control Systems-Design, Installation, and Test of, Piloted Aircraft, General Specification for.
MIL-A-8064	Actuators and Actuating Systems; Aircraft, Electromechanical, General Requirement for.
MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design and Installation Requirements for.
MIL-H-8890	Hydraulic Components, Type III, -65^{0} to $+450^{0}$, General Specification for.

4.0 Military Publications
(continued)

MIL-H-8775	Hydraulic System Components, Aircraft and Missiles, General Specification.
MIL-C-5503	Cylinders, Aeronautical, Hydraulic Actuating, General Requirements for.
MIL-I-5997	Instruments and Instrument Panels, Aircraft, Installation of.
MIL-I-18997	Indicator, Pressure, Panel Mounted or Case Supported, General Specification for.
MIL-I-7062	Indicators, Position, Control Surfaces, 28 Volt DC, General Specification for.
MIL-G-8402	Gages, Pressure, Dial Indicating, General Specification for.
MIL-G-7940	Gages, Liquid Quantity, Capacitor Type, Installation and Calibration of.
MIL-I-27544	Indicator, Liquid Oxygen Quantity.
MIL-P-26292	Pitot and Static Pressure Systems, Installation and Inspection of.
MIL-E-25499	Electrical Systems, Aircraft, Design and Installation of, General Specification for.
MIL-E-7080	Electric Equipment; Aircraft, Selection and Installation of.
MIL-G-21480	Generator System, Single Generator, Constant Frequency Alternating Current, Aircraft, Class C, General Specification for.
MIL-E-23001	Electric Generating System, Variable Speed Constant Frequency, Aircraft, General Specification for.
MIL-P-26517	Power Supply, Transformer-Rectifier, Aircraft, General Specification for.
MIL-I-27273	Inverter, Power, Static, General Specification for.
MIL-I-7032	Inverter, Aircraft, General Specification for.
MIL-W-5088	Wiring, Aircraft, Selection and Installation of.
MIL-C-55021	Cable, Twisted Pairs and Triples, Interval Hookup, General Specification for.

4.0 Military Publications
(continued)

MIL-L-27160	Lighting, Instrument, Integral, White, General Specification for.
MIL-L-25467	Lighting, Integral, Aircraft Instrument, General Specification for.
MIL-L-6503	Lighting Equipment, Aircraft, General Specification for Installation of.
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for.
MIL-S-8805	Switches and Switch Assemblies, Sensitive and Push, Snap Action, General Specification for.
MIL-B-83769	Batteries, Storage Lead Acid, General Specification for.
MIL-E-5400	Electronic Equipment, Airborne, General Specification for.
MIL-I-8700	Installation and Test of Electronic Equipment in Aircraft, General Specification for.
MIL-STD-188	Military Communications System.
MIL-HDBK-216	RF Transmission Lines and Fittings.
DH 1-4	Electromagnetic Compatibility.
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment.
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic Compatibility.
MIL-E-3845_	Environmental Control, Environmental Protection, and Engine Bleed Air Systems, Aircraft, General Specification for.
MIL-A-83116	Air Conditioning Subsystems, Air Cycle, Aircraft and Aircraft-Launched Missiles, General Specification for.
MIL-A-38339	Air Conditioners, Lightweight, Compact, Military, General Requirements for.
MIL-P-5518	Pneumatic Systems, Aircraft; Design Installation, and Data Requirements for.
MIL-P-8564	Pneumatic System Components, Aeronautical, General Specification for.

4.0 Military Publications
(continued)

MIL-D-8804	De-Icing Pneumatic Boot, Aircraft, General Specification for.
MIL-A-9482	Anti-Icing Equipment for Aircraft, Heated Surface Type, General Specification for.
MIL-D-19326	Design and Installation of Liquid Oxygen Systems in Aircraft, General Specification for.
MIL-D-8683	Design and Installation of Gaseous Oxygen Systems in Aircraft, General Specification for.
MIL-R-83178	Regulators, Oxygen, Diluter-Demand, Automatic Pressure-Breathing, General Specification for.
MIL-O-27335	Oxygen Systems, Survival Container Oxygen Kit, General Specification for.

APPENDIX B

COMPARISON OF SPECIFICATIONS, MILITARY TO COMMERCIAL

MILITARY PUBLICATIONS		COMMERCIAL PUBLICATIONS	
AFR 800-2	Program Management - Acquisition Management	FAR Volume III Part 25	Airworthiness Standards; Transport Category Airplanes
AFR 800-11	Life Cycle Costing (LCC)		
AFLCP/AFSCP 800-19	Joint Design-to-Cost Guide	FAR Volume VII Part 121	Certification and Operations; Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft
DOD Directive 5000.1	Acquisition of Major Defense System		
MIL-STD-847A	Format Requirements for Scientific and Tech. Reports prepared by or for the Dept. of Defense		
MIL-HDBK-127	Reliability Stress and Failure Rate Data for Electronic Equipment		
MIL-STD-781	Reliability Tests: Exponential Distribution		
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production		
MIL-A-8866	Airplane Strength and Rigidity -- Reliability Requirements, Repeated Loads, and Fatigue		
AFR 80-5	Reliability and Maintainability Programs for Systems, Subsystems, Equipment and Munitions - R&D		
DH 1-9	Maintainability	Paragraph	
MIL-HDBK-472	Maintainability Prediction		
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipments)	121.361 through 121.380	Maintenance and Preventive Maintenance
MIL-STD-471	Maintainability Verification/ Demonstration/Evaluation	25.611	Accessibility

MILITARY PUBLICATIONS		COMMERCIAL PUBLICATIONS	
		Paragraph	
DH 1-6	System Safety	25.1411 through 25.1415	Safety Equipment
MIL-STD-882	System Safety Program for Systems and Associated Subsystems and Equipment		
DH 1-3	Personnel Subsystems		
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities		
MIL-D-26239	Data, Qualitative and Quantitative Personnel Requirements Information		
MIL-V-38352	Value Engineering Program Requirements		
DH 1-1	General Index and Reference		
MIL-F-8785	Flying Qualities of Piloted Airplanes		
DH 1-2	General Design Factors	25.601	General Design
DH 1-X	Checklist of General Design Criteria		
DH 2-7	System Survivability (Classified)		
DH 2-8	Life Support		
DH 2-1	Airframe	25.601 through 25.657	General Design Materials, Fabrication, Fasteners, Material Strength and Design Properties
MIL-A-8860	Airplane Strength and Rigidity, General Specification for		
MIL-A-8861	Airplane Strength and Rigidity, Flight Loads		
MIL-C-8073	Core Material, Plastic Honeycomb, Laminated Glass Fabric Base, for Aircraft Structural Applications		

MILITARY PUBLICATIONS		COMMERCIAL PUBLICATIONS	
DH 2-1	Airframe (continued)		
MIL-R-7705	Radomes, General Specification for		
MIL-C-5462	Cover; Wing and Tail, Aircraft, General Specification for		
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structure	MIL-HDBK-5	(Joint effort DOD and FAA)
MIL-S-8806	Sound Pressure Levels in Aircraft, General Specification for		
MIL-A-9094	Arrester, Lightning, General Specification for Design of		
MIL-D-9129	Dischargers, Aircraft Electrostatic, General Specification for		
		Paragraph	
DH 2-2	Crew Stations and Passenger Accommodations	25.771	Pilot Compartment
MIL-STD-203	Aircrew Station Controls and Display Fixed Wing Aircraft	25.777	Cockpit Controls
MIL-STD-1333	Aircrew Station Geometry for Military Aircraft	25.787 through 25.789	Compartment Accommodations
MIL-K-25049	Knobs, Control, Equipment, Aircraft	25.781	Cockpit Control Knob Shape
MIL-STD-850	Aircrew Station Vision Requirements for Military Aircraft	25.773	Pilot Compartment View
MIL-W-7233	Windshield Wiper System, Electric, Aircraft General Requirements for	25.775	Windshields and Windows
MIL-R-83055	Rain Repellent Dispensing Systems Aircraft Windshield, General Specification for	121.215	Cabin Interiors

MILITARY PUBLICATIONS		Paragraph	COMMERCIAL PUBLICATIONS
MIL-STD-1511	Inflight Emergency Escape System, Aircraft, Requirements for	25.801 through 25.813	Emergency Provisions
MIL-S-9479	Seat System: Upward Ejection, Aircraft, General Specification for		
MIL-S-18471	System, Aircrew Automated Escape, Ejection Seat Type, General Specification for	121.291	Emergency Evacuation
MIL-S-83249	Slide, Escape, Aircraft, Inflatable, General Specification for	121.309 through 121.311	Emergency Equipment and Seat/Safety Belts
MIL-S-81018	Survival Kit Container, Aircraft Seat, with Oxygen, General Specification for		
MIL-S-81040	Survival Kit Container, Aircraft Seat, without Oxygen, General Specification for		
MIL-C-25913	Cartridge Actuated Devices, Aircraft Crew Emergency Escape, General Specification for		
MIL-S-38039	Systems, Illuminated, Warning, Caution and Advisory, General Specification for		
MIL-G-83063	Galley, Aircraft, General Requirements for		
MIL-A-8862	Airplane Strength and Rigidity, Landplane Landing and Ground Handling Loads	25.721 through 25.729	Landing Gear-General
MIL-L-8552	Landing Gear, Aircraft Shock Absorber (Air-Oil Type)	25.731 through 25.735	Wheels, Tires and Brakes
MIL-S-8812	Steering System; Aircraft, General Requirements for	121.289	Landing Gear: Aural Warning Device
MIL-W-5013	Wheel and Brake Assemblies, Aircraft		

MILITARY PUBLICATIONS		Paragraph	COMMERCIAL PUBLICATIONS
MIL-STD-1511	Inflight Emergency Escape System, Aircraft, Requirements for (continued)		
MIL-B-8584	Brake Systems, Wheel, Aircraft, Design of		
MIL-B-8075	Brake Control Systems, Anti-Skid, Aircraft Wheels, General Specification for		
MIL-A-8591	Airborne Scores and Associated Suspension Equipment; General Design Criteria for		
AH 2-3	Propulsion and Power	25.901 through 25.939	Powerplant - General
MIL-STD-1534	Engines, Aircraft, Gas Turbine, Technical Design Requirements		
MIL-E-5007	Engines, Aircraft, Turbojet and Turbofan, General Specification for	Amendment 25.11	Miscellaneous Aircraft Propulsion System Design Requirements
MIL-S-38399	Starter, Pneumatic, Aircraft Engine, General Specification for	25.1011 through 25.1025	Oil System
MIL-S-27266	Starter, Engine, Cartridge and Pneumatic Shaft Drive, General Specification for	25.1041 through 25.1045	Cooling
MIL-P-8686	Power Units; Aircraft Auxiliary, Gas-Turbine-Type, General Specification for	25.1091 through 25.1127	Air Induction and Exhaust
MIL-D-7602	Drive, Turbine, Air, Aircraft Accessory, General Specification for	25.1141 through 25.1165	Powerplant Controls and Accessories
MIL-G-6641	Gearbox, Aircraft Accessory Drive, General Specification for		
MIL-D-27729	Detecting Systems; Flame and Smoke, Aircraft and Aerospace Vehicle, General Performance, Installation and Test of	25.1181 through 25.1203	Powerplant Fire Protection

MILITARY PUBLICATIONS		COMMERCIAL PUBLICATIONS	
		Paragraph	
MIL-[illegible]	Propulsion and Power (continued)		
MIL-F-7372	Fire and Overheat Warning Systems, Continuous, Aircraft: Test and Installation of		
MIL-C-8188	Corrosion Preventive Oil, Gas Turbine Engine, Aircraft Synthetic Base		
MIL-F-38363	Fuel System, Aircraft, General Specification for	25.951 through 25.1001	Fuel System/Components
MIL-F-8615	Fuel System Components: General Specification for	Amendment 25.14	Fuel System Lightning Protection
MIL-T-18847	Tanks, Fuel, Aircraft, Auxiliary External, Design and Installation of		
MIL-F-9490C	Flight Control Systems-Design, Installation, and Test of, Piloted Aircraft, General Specification for	25.651 through 25.701	Control Surfaces
MIL-A-8064	Actuators and Actuating Systems: Aircraft, Electro-Mechanical, General Requirement for	ARINC Report 417	Auto Flight Control
MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design and Installation Requirements for	25.1435	Hydraulic System
MIL-H-8890	Hydraulic Components, Type III, -65° to +450°, General Specification for	Amendment 25.13	Hydraulic System for Transport Category Airplanes
MIL-H-8775	Hydraulic System Components, Aircraft and Missiles, General Specification		
MIL-C-5503	Cylinders, Aeronautical,		

MILITARY PUBLICATIONS		COMMERCIAL PUBLICATIONS	
		Paragraph	
MIL-I-5997	Instruments and Instrument Panels, Aircraft, Installation of	25.1303	Flight and Navigation Instruments
		25.1305	Powerplant Instruments
MIL-I-18997	Indicator, Pressure, Panel Mounted or Case Supported, General Specification for	25.1321 through 25.1337	Instruments: Installation
MIL-I-7062	Indicators, Position, Control Surfaces, 28 Volt DC, General Specification for	121.301 through 121.307	Instrument Requirements
MIL-G-8402	Gages, Pressure, Dial Indicating, General Specification for	ARINC Spec. #408	Air Transport Indicator Cases and Mounting
MIL-G-7940	Gages, Liquid Quantity, Capacitor Type, Installation and Calibration of		
MIL-I-27544	Indicator, Liquid Oxygen Quantity		
MIL-P-26292	Pitot and Static Pressure Systems, Installation and Inspection of		
MIL-E-25499	Electrical Systems, Aircraft, Design and Installation of, General Specification for	25.1351 through 25.1363	Electrical Systems and Equipment
MIL-E-7080	Electric Equipment; Aircraft, Selection and Installation of		
MIL-G-21480	Generator System, Single Generator, Constant Frequency Alternating Current, Aircraft, Class C, General Specification for		
MIL-E-23001	Electric Generating System, Variable Speed Constant Frequency, Aircraft, General Specification for		
MIL-P-26517	Power Supply, Transformer-Rectifier, Aircraft, General Specification for		
MIL-I-27273	Inverter, Power, Static, General Specification for		

MILITARY PUBLICATIONS		Paragraph	COMMERCIAL PUBLICATIONS
MIL-E-25499	Electrical Systems, Aircraft, Design and Installation of, General Specification for (continued)		
MIL-I-7032	Inverter, Aircraft, General Specification for		
MIL-W-5088	Wiring, Aircraft, Selection and Installation of	ARINC Report #306, Sec. 2.0	Aircraft Wiring
MIL-C-55021	Cable, Twisted Pairs and Triples, Interval Hookup, General Specification for		
MIL-L-27160	Lighting, Instrument, Integral, White, General Specification for	25.1381 through 25.1401	Lighting
MIL-L-25467	Lighting, Integral, Aircraft Instrument, General Specification for		
MIL-L-6503	Lighting Equipment, Aircraft, General Specification for Installation of	Amendment 25.27	Anticollision Light Standards
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for	Amendment 25-30	Position Light System Dihedral Angles
MIL-S-8805	Switches and Switch Assemblies, Sensitive and Push, Snap Action, General Specification for		
MIL-B-83769	Batteries, Storage Lead Acid, General Specification for		
MIL-E-5400	Electronic Equipment, Airborne, General Specification for	25.1431	Electronic Equipment
		Amendment 121-89	Doppler Radar and Inertial Navigation Systems
MIL-I-8700	Installation and Test of Electronic Equipment in Aircraft, General Specification for	ARINC Report #304	Electronic Installation Guidance Material
MIL-STD-188	Military Communications System		
MIL-HDBK-216	RF Transmission Lines and Fittings	ARINC Report #306	Guidance for Designers of Aircraft

MILITARY PUBLICATIONS

MIL-E-5400	Electronic Equipment, Airborne, General Specification For (continued)
DH 1-4	Electromagnetic Compatibility
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic Compatibility
MIL-E-38453	Environmental Control, Environmental Protection, and Engine Bleed Air Systems, Aircraft, General Specification for
MIL-A-83116	Air Conditioning Subsystems, Air Cycle, Aircraft and Aircraft-Launched Missiles, General Specification for
MIL-A-38339	Air Conditioners, Lightweight, Compact, Military, General Requirements for
MIL-P-5518	Pneumatic Systems, Aircraft; Design Installation, and Data Requirements for
MIL-P-8564	Pneumatic System Components, A Aeronautical, General Specification for
MIL-D-8804	De-Icing Pneumatic Boot, Aircraft, General Specification for
MIL-A-9482	Anti-Icing Equipment for Aircraft, Heated Surface Type, General Specification for

COMMERCIAL PUBLICATIONS

ARINC Report #403	Guidance for Designers of Airborne Electronic Equipment
ARINC Report #404	Air Transport Equipment Cases and Racking
ARINC Report #406A	Airborne Electronic Equipment Standardized Interconnections and Index Pin Codes
ARINC Report #414	General Guidance for Equipment and Installation Designers

Paragraph	
25.831	Ventilation
121.219	Ventilation
25.833	Heating Systems
25.841 and 25.843	Pressurization

MILITARY PUBLICATIONS		COMMERCIAL PUBLICATIONS	
		Paragraph	
MIL-D-19326	Design and Installation of Liquid Oxygen Systems in Aircraft, General Specification for	25.1441 through 25.1453	Oxygen Equipment and Supply
MIL-D-8683	Design and Installation of Gaseous Oxygen Systems in Aircraft, General Specification for	121.327 through 121.333	Supplemental Oxygen Requirements
MIL-R-83178	Regulators, Oxygen, Diluter-Demand, Automatic Pressure-Breathing, General Specification for		
MIL-0-27335	Oxygen System, Survival Container Oxygen Kit, General Specification for		

APPENDIX C

INITIAL QUESTIONNAIRE

(with summarized answers)

19 August 1974
2-5000-M/C-001

To: See Attached List

Subject: Evaluation of Military and Commercial Airplane Practices

The Boeing Company is performing a study for the Air Force to compare commercial and military practices on airplane programs so that military program management and procurement may benefit from cost saving/cost reduction techniques proven on commercial programs. Boeing was selected for the study because of its vast experience in both areas.

Questionnaires are being prepared and sent to those with experience in both types of programs to cover the disciplines of planning, management, design, manufacturing, test and support. The questionnaires are designed to pinpoint areas of major difference so that follow-on evaluation can be concentrated where it will have the potential of doing the most good.

Each participant is requested to provide a candid answer and return the questionnaire as soon as possible but not later than 30 August 1974. Any questions should be directed to the undersigned on 237-7565.

Dean L. Quigley

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Program Management

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	Degree of preliminary planning				
2.	Number of trade studies				
	2a. Configuration				
	2b. Cost				
	2c. Customer				
	2d. Competition				
	2e. Subcontractor				
3.	No. of controls				
4.	Size of team				
5.	Freedom for long-range planning				
6.	Customer coordination				
7.	Vendor/Assoc./Sub. involvement				
8.	Industry involvement				
9.	Directives (Command Media)				
10.	Use of current state of technology				
11.	Upper management review				
12.	Time required for decision making process.				
13.	Written correspondence				
14.	Phone conversations				
15.	No. of file cabinets for records				
16.	Establishment of Program Goals				
17.	Establishment of Design-to-Cost Goals				
18.	Marketing involvement				
19.	Facilities requirements				
20.					
21.					
22.					

23. OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Contracts

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of "boiler plate" pages		✓		
2.	Pages per contract	✓			
3.	Complexity of "boiler plate" contents . .			✓	
4.	Amount of documentation		✓		
5.	Pre-negotiation inquiries				✓
6.	Post-award inquiries		✓		
7.	Post-delivery inquiries	✓			
8.	Number of negotiations			✓	
9.	Number of personnel involved				
	9a. Customer			✓	
	9b. Boeing			✓	
10.	Complexity of contract.		✓		
11.	Number of contract changes.	✓			
12.	Time to negotiate contract (productive time)			✓	
13.	Calendar time from start to finish. . . .				✓
14.	Taxes - Local/Federal		✓		
15.	Facilities Requirements		✓		
16.					
17.					
18.					
19.					

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Finance

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of specifications.	_	II	_	_
2.	No. of pages per spec.	II	II	_	_
3.	Amount of documentation.	IIII	II	_	_
4.	Detailed amount of documentation	IIIII	I	_	_
5.	No. of cost evaluations.	II	I	II	_
6.	No. of trade studies	I	III	II	_
7.	Amount of customer coordination.	IIIII	III	_	_
8.	Number of personnel involved	IIIII	II	II	_
9.	Percent learning curve	_	III	III	_
10.	Initial unit price	IIII	I	I	_
11.	Average unit price	_	IIII	II	I
12.	Fee Negotiated	_	II	_	IIII
13.	Overhead charges	_	I	I	II
14.	Post-delivery customer queries	I	IIII	I	II
15.	Facilities Requirements.	_	I	IIIII	I
16.					
17.					
18.					
19.					

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Engineering - Preliminary Design

Instruction. Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of configurations				
2.	No. of parametric studies				
3.	No. of evaluations				
4.	Time to make evaluations				
	4a. By Customer				
	4b. By Boeing				
5.	No. of people at evaluation meetings				
	5a. Customer				
	5b. Boeing				
6.	No. of specs. to be complied with				
7.	Amount of detail in specs.				
8.	No. of final specifications				
9.	Amount of detail in final specs				
10.	No. of documents generated				
11.	No. of document pages generated				
12.	Use of wind tunnel				
13.	Use of computer				
14.	No. of personnel assigned				
15.	No. of meetings				
16.	No. of people at meetings				
	16a Customer				
	16b Boeing				
17.	No. of trips to potential customer				
18.	No. of people on each trip				
19	No of visits by potential customer				
20.	No. of people on visits				
21.	Elapse time to perform P.D.				
22.	Amount of dollars spent on P.D.				
	22a Boeing Expense				
	22b. Customer Expense				

Phase: Engineering - Preliminary Design (continued)

ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
23. Completeness of design by P.D.	—	IIII	[illegible]	I
24. Amount of Staff/Project coordination	—	III	[illegible]	II
25. Facilities Requirements	II	IIII	[illegible]	—
26.				
27.				
28.				
29.				

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Engineering - Project

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of specifications				
2.	No. of pages in specs				
3.	No. of documents				
4.	No. of pages in documents				
5.	No. of drawings				
6.	Quality of drawings				
7.	Time to make drawings				
8.	Time to check drawings.				
9.	Time to release drawings.				
10.	No. of design changes				
11.	Time to change approval				
	11a. Major Changes.				
	11b. Minor Changes.				
12.	No. of Mockups				
13.	No. of Design Reviews				
	No. of Attendees				
	13a. Customer.				
	13b. Boeing				
14.	No. of new vendor items				
15.	No. of liaison changes				
16.	Time to liaison change approval				
	16a. Major				
	16b. Minor				
17.	Inplant Coordination.				
18.	Customer Coordination				
19.	No. of trade studies				
20.	No. of pages in studies				
21.	Use of computer				
22.	No. of personnel assigned				
23.	No. of meetings				
24.	No. of personnel at meetings				
	24a. Customer				
	24b. Boeing				
25.	No. of trips to customer.				
26.	No. of personnel on each trip				
27.	No. of visits by customer				
28.	No. of personnel on visits.				
29.	Maintainability specs				
30.	Reliability specs				
31.	Safety specs.				
32.	Time spent designing				
33.	Time spent writing.				
34.	Application of new innovations.				
35.	Amount of Manufacturing liaison				
36.	Facilities Requirements				

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Engineering - Technology

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	Amount of support provided.				
2.	No. of studies.				
3.	No. of evaluations				
4.	Time to make evaluations				
	4a. By Customer.				
	4b. By Boeing				
5.	No. of people at evaluation meetings. .				
	5a. Customer				
	5b. Boeing				
6.	No. of specs. to be complied with . . .				
7.	Amount of detail in specs.				
8.	No. of final specifications				
9.	Amount of detail in final specs				
10.	No. of documents generated				
11.	No. of document pages generated				
12.	Use of wind tunnel				
13.	Use of computer				
14.	No. of personnel assigned				
15.	No. of meetings				
16.	No. of people at meetings				
	16a. Customer				
	16b. Boeing				
17.	No. of trips to potential customer. . .				
18.	No. of people on each trip.				
19.	No. of visits by potential customer . .				
20.	No. of people on visits				
21.	Amount of time spent on Project Supt...				
22.	Amount of time spent on P.D. Support. .				

Phase: Engineering - Technology (continued)

	ITEM	MUCH MORE	MORE	SAME	LESS
		RATING (MILITARY TO COMMERCIAL)			
23.	Application of new innovations.	[illegible]	[illegible]	[illegible]	
24.	Application of recent research results. . . .	[illegible]	[illegible]	[illegible]	I
25.	Alignment of research with next generation A/C	II	I	[illegible]	
26.	Awareness of new innovations by suppliers . .	I	[illegible]	[illegible]	I
27.					
28.					
29.					
30.					

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Test

Instruction: Place check in Rating column which most closely matches experience.

ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1. No. of technical specs applied.				
2. No. of pages per spec				
3. No. of documents required				
4. No. of pages per document				
5. No. of tests required				
5a. Fuselage				
5b. Subsystems				
5c. Component				
5d. First Article				
6. Flight Tests				
Development				
Delivery				
6a. Ground preparation time				
6b. Flight time				
6c. Reflight items				
7. No. of copies of reports, documents, etc.				
8. Customer reviews.				
9. Extensiveness of test plan				
10. Changes to test plans				
11. Elapsed time for test plan approval . . .				
12. Facilities Requirement.				
13.				
14.				
15.				
16.				

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Manufacturing

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of Customer specifications				
2.	Depth of details of specs				
3.	Amount of standardization				
4.	Amount of commonality				
5.	No. of Materials & Process spec				
6.	Closeness of tolerances				
7.	Quality Assurance				
8.	Production rates				
9.	Flexibility of schedule.				
10.	Volume of engineering changes.				
11.	Lost time awaiting decision				
12.	No. of out-of-sequence mods				
13.	Manpower				
	13a. Number of people				
	13b. Rate of loading				
14.	No. of tools				
15.	No. of first article checks.				
16.	No. of tests				
17.	Depth of tests				
18.	Amount of travel				
19.	No. of Meetings				
20.	Amount of direct coordination with customer				
21.	Cost to manufacture same no. of units . .				
22.	Facilities Requirements.				
23.					
24.					
25.					
25.					

Phase: Manufacturing

ITEM	RATING (MILITARY TO COMMERCIAL)			
	MUCH MORE	MORE	SAME	LESS

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Manufacturing

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of Customer specifications				✓
2.	Depth of details of specs				✓
3.	Amount of standardization				✓
4.	Amount of commonality				✓
5.	No. of Materials & Process spec		✓		
6.	Closeness of tolerances			✓	
7.	Quality Assurance			✓	
8.	Production rates				
9.	Flexibility of schedule				✓
10.	Volume of engineering changes				✓
11.	Lost time awaiting decision				✓
12.	No. of out-of-sequence mods				✓
13.	Manpower				
	13a. Number of people				✓
	13b. Rate of loading				✓
14.	No. of tools				✓
15.	No. of first article checks				✓
16.	No. of tests				✓
17.	Depth of tests				✓
18.	Amount of travel				✓
19.	No. of Meetings				✓
20.	Amount of direct coordination with customer			✓	
21.	Cost to manufacture same no. of units			✓	
22.	Facilities Requirements				✓
23.					
24.					
25.					
25.					

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Materiel

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of specifications to apply.				
2.	No. of pages per specifications				
3.	Negotiation time of purchases				
4.	Quality of purchases.				
5.	Amount of documentation required.				
6.	No. of pages per document				
7.	Responsiveness of sellers				
8.	Investigation of sellers				
9.	Price of similar item				
10.	Post-delivery customer queries.				
11.	No. of people for equivalent task				
12.	Amount of travel.				
13.	No. of meetings				
14.	Amount of correspondence generated. . . .				
15.	Facilities requirements				
16.					
17.					
18.					
19.					

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Product Assurance

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	Maintainability				
	1a. No. of specifications.				
	1b. Depth of specs				
	1c. No. of documents				
	1d. No. of document pages.				
	1e. No. of reports				
	1f. No. of report pages.				
	1g. Guarantee requirements				
2.	Reliability				
	2a. No. of specifications.				
	2b. Depth of specs				
	2c. No. of documents				
	2d. No. of document pages.				
	2e. No. of reports				
	2f. No. of report pages.				
	2g. Guarantee requirements				
3.	Safety				
	3a. No. of specifications.				
	3b. Depth of specs				
	3c. No. of documents				
	3d. No. of document pages.				
	3e. No. of reports				
	3f. Guarantee requirements				
4.	No. of people				
5.	Drawing review required				
6.	No. of meetings				
7.	No. of personnel at meetings.				
8.	No. of trips				
9.	No. of trade studies.				
10.	Amount of coordination with the customer. .				
11.	Use of experience data				
12.	Support predictions				
13.	Support guarantees				
14.	Facilities requirements				
15.					
16.					
17.					
18.					

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Service Support - Maintenance

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of inspections	I	IIII	I	
2.	Quality of inspections			IIII	II
3.	Ground Support equipment		II		I
	3a. Flightline items		III	I	
	3b. Shop items		II	I	II
	3c. Overhaul items		III	I	I
4.	Facilities		I	II	III
5.	Frequency of scheduled maintenance . . .	I	III		I
6.	Amount of scheduled maintenance.	I	IIII		I
7.	Amount of documentation	I	IIII	I	
8.	Amount of customer coordination	I	III		
9.	No. of meetings.	II	III		I
10.	Extensiveness of maintenance studies . .		III		III
11.	Freedom to propose new maintenance support planes				IIII
12.	Facilities Requirements.		III		II
13.	Maintenance Labor Expended / Job		I		
14.					
15.					
16.					

OTHER:

1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information:

RETURN TO: D. L. QUIGLEY
Ext. 237-7565
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Service Support - Manuals

Instruction: Place check in Rating column which most closely matches experience.

	ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1.	No. of specifications applied.	III			
2.	No. of pages per spec.	I			I
3.	No. of documents required.	III			
4.	No. of pages per document.	I	I		I
5.	No. of reports required.	I	II		
6.	No. of pages per report.	I	I	I	
7.	No. of copies per request.	II	I		
8.	Time to write.		III		
9.	Time to print.		III		
10.	Use of current methodology				III
11.	Contents				
	11a. Details		III		
	11b. Clarity		I	I	
	11c. Changeability			I	II
12.	Accuracy	I		II	
13.	Time required to make changes.	I	II		
14.	Coordination	I			
	14a. Customer	III			
	14b. Inplant	I		I	
15.	No. of meetings.	III			
16.	Attendance per meeting				
	16a. Customer	I	I		
	16b. Boeing	II		I	
17.	Validation requirements.	II	I		
18.	Verification requirements.	II			
19.	Cost per manual page		II		
20.	Facilities requirements		II	I	
21.					
22.					
23.					
24.					

OTHER: 1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

RETURN TO: D. L. QUIGLEY
Ext. 237-7566
M/S 92-23

QUESTIONNAIRE

Subject: Comparison of Military to Commercial Practices in new airplane procurement.

Phase: Service Support - Training

Instruction: Place check in Rating column which most closely matches experience.

ITEM	RATING (MILITARY TO COMMERCIAL) MUCH MORE	MORE	SAME	LESS
1. Training (General)				
1a. No. of specifications	I	I		
1b. Depth of specifications		II		
1c. No. of documents generated	II			
1d. No. of pages per document		I		I
1e. No. of reports required	I	I		
1f. No. of pages per report		I		
1g. Amount of customer coordination time.	II			
2. Maintenance Training				
2a. No. of students		II		
2b. Caliber of students		I	I	
2c. Length of classes				II
2d. Material taught		I	I	
~~2e. Handout material~~		I	I	
3. Flight Training				
3a. No. of students				I
3b. Caliber of students				I
3c. Length of classes			I	
3d. Material taught			I	
3e. Customer control of course		I		
4. Training at Customer Site			I	I
5. Amount of retraining			I	I
6. Amount of Upgrade Training			I	I
7. Facilities requirements.		I		I
8.				
9.				
10.				
11.				

OTHER: 1. Please submit names of other individuals to whom questionnaire should be sent:

2. Is there a better way to acquire this information?:

APPENDIX D

SECOND QUESTIONNAIRE

1. Letter, 2-5000-M/C- (see below)
2. Attachment I - General questions, sent to all
3. Attachment II- Specific questions, sent to individual discipline

Letter	Discipline Addressee
-002	Manufacturing
-003	PM & Engineering
-004	Finance
-005	Test
-006	Materiel
-007	Product Assurance
-008	Maintenance
-009	Training
-010	Manuals

19 September 1974
2-5000-M/C

To: See Attached List

Subject: Evaluation of Military and Commercial Airplane Practices

Reference: My memo 2-5000-M/C-001 dated August 19, 1974

The response to reference was encouraging and the cooperation evidenced by this response is truly appreciated. The questionnaire fulfilled its purpose in basically pinpointing areas of differences thus indicating where concentration of effort should be directed.

A great number of you recommended interviews with key personnel, either individually or in groups. This will be done. Many of you gave specific instances of cost-savings or people to see to obtain this data. These leads are being followed.

The attached list of questions have been derived from the results to the reference and other sources. You are requested to provide answers to the questions and return them by September 30, 1974. Interviews for further discussion may be requested, based on your answers, other inputs and your recommendations.

For your information, my telephone number has been changed to 237-0390 although the mail stop remains at 92-23.

D. L. Quigley

Attachments:
I. General Questions
II. Specific Questions

ATTACHMENT I

GENERAL

Analysis of the answers to the questionnaire, which were sent company-wide in all phases of airplane acquisition and production, show that basically the difference between commercial and military programs is a people problem in that more people are involved from the military customer side which naturally leads to a similar number of Boeing counterparts and to more correspondence, i.e., studies, reports, meetings, telephone calls, trips, visits, documents, specifications, etc. The results of questionnaire also indicated little difference in engineering design, testing and quality of product. This would mean the government could save time (which is money) by adjusting the degree to which people are involved on a direct interface. With the above in mind, answers to the following questions are requested.

1. What area of your responsibility is more heavily affected? (i.e. planning, managing, scheduling, accounting, testing)

2. Are there particular military specifications or standards which can be pinpointed as the causes?

3. What part of these specs and standards need to be changed and why?

4. Have you data or is data available from which the saving to Boeing (and consequently, to the government) can be determined (in manhours, dollars, flight time, elapsed time, or a combination of these), if the specs were changed?

GENERAL (continued)

5. If assigned to, supporting, or with first hand knowledge of a derivative program, is there anything specific you are doing on your program which is better or worse than that done or being done on a similar program, i.e., T43A vs AWACS vs AABNCP vs KC-135 vs Air Force One vs NASA Shuttle vs Peace Station vs YC-14?

6. Can you name specific technical requirements that need to be revised, in part or in whole, which would result in reducing contract costs without reduction in quality? This could include deletion, updating, revising or rewriting by loosening or tightening tolerances, elimination of certain tests (temperature, duration, inspection), etc.

7. On the other hand, assuming the requirements are valid, are there better ways to comply? If so, what specs and how?

8. Do you know of examples, trade studies, investigations, histories, presentations or reports and by whom which may be available to research for further information.

SPECIFIC

A summary of the answers to the questionnaire is attached for your review. It does not vary greatly from the general analysis. Based on this summary, several specific questions would appear to be appropriate

1. Corporate data on cost to manufacture the same number of units, manhours per AMPR pound, would indicate little difference between military and commercial program. Yet the results to the questionnaire indicate the opposite. Can this be explained?

2. Since all agree that there is lost time while awaiting a decision of the military customer on making or approving changes and this apparently causes a greater number of out-of-sequence modifications, what means can be employed to definitize what this lost time costs?

3. Does the lower production rate of the military increase the cost of the end product? If so, how much and what affects these costs? Is there an optimum rate?

SPECIFIC (general)

4. Do the greater number of military specs, increased tolerances, more quality assurance, and greater number and greater depth of tests provide a better product? Why?

5. What is the ratio of administrative manhours to hardware manhours on military/derivative programs and on commercial programs?

6. Note other specifics.

SPECIFIC

1. One comment was made that missiles and electronic systems should be considered separate from airplanes. This has been interpreted to mean that if the missile or electronic system is a subsystem on an airplane than the program should be handled by airplane people. The Air Forces does not do this. Whatever element has the most money involved has the Systems Program Office. For instance, the T-43A SPO was in ASD (Aeronautical Systems Division) while the AWACS and Command Post SPOs are in ESD (Electronic Systems Division, both of AFSC. What impact do you believe this policy has on a program? Can you suggest a more cost effective approach?

2. Another comment suggested the government evaluate each company in the industry periodically to avoid having to give the same basic data pertaining to program management, experience, skills, and other background data in every proposal. Do you agree with this approach?

   Do you believe this change would have any impact on program costs? If so, where and how much?

   If this policy were established and the government set up a central procurement data bank, what kind of information do you believe should be included; i.e., what kind of evaluation should be made? Limit your ideas to airplane manufacturers.

3. Review of the 747 program requirements reveals a similar set of directives or command media for both military and commercial programs. However, answers to the questionnaire indicate the opposite. What is your personal experience pertaining to implementation of these requirements?

SPECIFIC (continued)

4. A nearly universal complaint on military programs is the long time it takes to get a decision. Is there a way that this lost time or time-awaiting decision can be equated to the cost on a program? How can this be improved and still allow DoD to maintain control?

5. Assuming that military requirements are valid, can you suggest a better or less expensive way to implement them?

6. With all the controls, regulations, specifications, documentation, does the military customer, as a general rule, receive a better quality product from industry? If not what do they gain?

7. How does the lack of freedom in long-range planning impact the cost of military products? What needs to be done to change this?

8. Comment has been made that on commercial programs engineers spend 100% of their time engineering while on military programs it is 40% engineering and 60% on paperwork. Is this true in your experience? Does this mean that it takes $2\frac{1}{2}$ times longer to do the same job? Are all engineers affected? Lead engineers? Supervisors?

SPECIFIC (continued)

9. A study on commercial programs has indicated that over half of all engineering changes are made because of design errors. Does the necessity of having to comply with military specifications and requirements reduce this problem? What do you think will reduce errors with cost-effectiveness?

10. What portion of your total Boeing experience is on military programs? Within the last five years?

11. In your opinion is an adequate balance established between performance and cost during the initial program planning?

12. What is the process for major program decisions?

13. Is a specific unit cost target established and worked toward?

14. What is your opinion on establishing a second source for high quantity production items?

15. What type of project offers the greatest opportunity for individual motivation and growth?

16. Are standardization and commonality emphasized?

16 September 1974
2-5000-M/C-004

ATTACHMENT II

SPECIFIC

1. Does the government requirement for completion of the 633 form and for audit generate more workload for the Finance personnel working on a military program than those working on a commercial program? If so, how much and how could it be reduced?

2. Nearly all answers to the initial questionnaire indicate there is considerable lost time on military programs while waiting for a decision from the customer, both during the proposal and during production. Are there data available which would provide what this lost time costs?

3. Are more personnel required for Costs and Schedules support on military programs? If so, do you have suggestions on how to lower the workload?

4. On current derivative programs some of you indicated that we are not reimbursed for the risk involved for holding positions in the production schedule, have you recommendations on how this might be handled?

SPECIFIC (continued)

5. What effect would the inclusion of a commercial warranty program have on the price of military contracts. Would a warranty program be realistic for the military?

6. Is there a difference between military and commercial programs in the amount of time spent by Finance for cost estimating in support of subcontract/vendor work? Why?

7. There are signs that the government may be changing or waiving some financing regulations in case of derivatives. For example, cost of money has been allowed in the Command Post Logistics contract for spares. What other ASPRS, etc. are being or could be changed or waived that would help to resolve some of the money problems imposed on a contractor?

8. Other Specifics?

17 September 1974
2-5000-M/C-005

ATTACHMENT II

SPECIFIC

1. Much has been written on the length of military flight test programs over commercial and subsequent increased cost but if we take out the maintainability, reliability and personnel subsystem tests (which the airline customers, in effect, do for us) and the climatic tests, the flight test program contain about the same number of flight hours. There is also about the same calendar time between first flight and first delivery or certification. If this is true, what is the cause for the increased cost of a military flight program?

2. What changes do you believe the government should make to the present requirements for maintainability, reliability, PSTE, climatic and lead-the-fleet testing for them to be more cost-effective?

3. What test requirements do you consider valid for a pure military program but superfluous for derivative programs and which have been imposed on current derivatives?

4. The comment has been made that rigidity of military testing increases the cost. For instance, if a test cannot be completed due to equipment failure, the military cancel the test while Boeing, on a commercial program, will alter the test program, without shutdown or landing, to accomplish another requirement. Does this occur often enough to warrant further investigation?

17 September 1974
2-5000-M/C-006

ATTACHMENT II

SPECIFIC

1. The initial questionnaire answers indicate the price of a part for a military program is more than a similar part for commercial programs. When buying a part from a vendor or subcontractor, what are the differences in requirements for commercial and military parts that cause the price differential?

2. How much difference, percentage wise, is the price?

3. What is your estimate on the portion of the price of a commercial part that is due to warranty program?

4. When Boeing releases a specification for bid, does competition provide a bid that is realistic or do we require a price breakdown? Have we made our own estimate of the approximate cost? Who in Boeing decides?

5. With the addition specifications, do military parts have a greater acceptance rate? How much?

6. What reasons do suppliers give when they decline or resist bidding on parts for military programs?

7. Are there differences in the amount and form of test and acceptance data generated by a supplier for a military product? If so, what?

8. Is the effort (number of people) greater for the Boeing Material department for a military or commercial program assuming an equal end product? If so, why?

SPECIFIC (continued)

9. There are indications that the government may be changing or waiving some procurement regulations in the case of derivatives. What ASPRs, etc. could be changed or waived that would help contractors procure parts at a lower price without affecting quality?

10. The nearly unanimous comment, that there is considerable lost time on military programs while waiting for a decision from the customer, would indicate this results in higher prices. What is your experience? If so, how does this increase the price?

11. Another comment suggested the government evaluate each company in the industry periodically to determine those who are qualified from the management and facility standpoint and thus eliminate a lot of boiler-plate during proposals. Do you agree? Please comment on this approach.

If this policy were established and the government set up a central procurement data bank, what kinds of information do you believe should be included?

18 September 1974
2-5000-M/C-007

ATTACHMENT II

SPECIFIC

1. Product Assurance (PA) is a part of both commercial and military airplane programs. What are the differences in PA assignments, workloads, and completeness of job?

   What methods are used to compare the results of the PA efforts? Can you give examples?

2. Is the necessary data available to support PA activities in each type program? If not, what kind of information is needed?

3. For a military program, do the additional requirements, and the manpower to implement these requirements, result in lower support costs and/or a better airplane for the customer as compared to a commercial program with considerably less of this kind of effort during the design phase?

   What is your estimate of the manpower cost difference for this effort between commercial and military programs?

18 September 1974
2-5000-M/C-008

ATTACHMENT II

SPECIFIC

1. For a military program does the additional maintainability/maintenance requirements, and the manpower to implement them, result in lower support costs and/or a better airplane for the customer as compared to a commercial program with considerably less of this kind of effort during the design phase?

   What is your estimate of the manpower cost difference for this effort between military and commercial programs?

2. Can the commercial basic maintenance philosophy of fewer inspections and requirements and no-overhaul/fix-when-failed be realistically extended to the military environment, assuming similar utilization? Assuming lower utilization with a high readiness posture? Why, in each case?

3. What differences are there in the support provided to the customers or to our field service engineers in military and commercial programs?

4. What is the ratio of quantity of spares ordered by commercial and military customers (base your answer on percentage of airplane price)?

   What are the differences in spares provisioning, stockage, usage and control?

5. Do the maintenance manuals provide adequate and pertinent information in the usable form to the mechanics of both types of customers?

SPECIFIC (continued)

6. Would the use of microfilm publications as is common with commercial customers, work in the current military environment? If not, what changes would be required?

7. Do you have data on the savings to the commercial customer when the manuals were changed from hard copy to microfilm?

8. Would the current commercial practice, that of obtaining engineering drawings and making or subcontracting peculiar ground support equipment, result in the same cost-effectiveness and quality for the military as it did for commercial programs? If not, why?

SPECIFIC

1. Assuming derivative programs and the training of experienced personnel, do the additional requirements, and the manpower to implement these requirements, result in better trained people as compared with similar students on a commercial program?

   If the answer is no, is data available for which a cost comparison could be established? Is there a difference in cost to implement an equal level of training? Why?

2. Are there things being accomplished on commercial training programs that would benefit the military either in better training or less expensive training that could be adapted to the military programs or derivative programs?

   Please list with the advantages.

19 September 1974
2-5000-M/C-010

ATTACHMENT II

SPECIFIC

1. Would the use of microfilm, as is common with commercial customers, work in the current military environment? If not, what changes would be required?

   Do you have data on the savings to the commercial customer when the change from hard copy manuals to microfilm was made?

2. For a military program, do the additional requirements, and the manpower to implement them, result in better manuals for the customer as compared to a commercial program with considerably less of this kind of effort during the planning and preparation phases?

   Is there a difference in manpower cost between commercial and military programs? If so what are the primary reasons. Can you identify specific requirements causing this difference?

3. The nearly unanimous comment, that there is considerable lost time on military programs while waiting for a decision from the customer, would indicate this results in higher costs. What is your experience? If positive, how does this increase the cost?

APPENDIX E

DESIGN CRITERIA

MILITARY VS CIVIL

1970 STUDY

MILITARY VS. CIVIL CRITERIA

Military missions like Tanker, Airborne Command Post, and others have a high degree of similarity to the airline use, and military procurement of commercially certificated airframes provides benefits to the military which are unavailable through other methods of procurement.

- Protection against cost overruns--fixed price.
- Commercial market competition provides a more efficient airframe proven in commercial operation. It provides additional incentive to remain cost and performance competitive by applying engineering judgment and an "acceptable risk" philosophy based on past experience to eliminate or reduce design and test criteria which may be considered to be too conservative when viewed agai t actual airc aft usage.
- Nonrecurring costs associated with original development and product improvement are shared by a broader base provided unnecessary Mil Spec compliance is eliminated.

We have taken a brief wholesale look at over 400 Mil Specs for a first in-house cut at what their impact on the 747 might be.

The impact appears to be anywhere from \$10M to \$150M+ of nonrecurring, depending upon the cost effectiveness of the Mil Spec decision process.

Although a wide variety of differences exist between Boeing commercial practice and military spec practice, they do have common objectives like:

- Safety
- Increased efficiency
- Enhancing utility

The differences tend to reduce to worst case conditions versus margin over average experience like examples in Attachment I listed below.

a. Electronic Component Environment Comparison
b. Fatigue Test Comparison
c. Structural Tests Comparison
d. Design Load Comparison
e. Corrosion Protection Comparison
f. Engine Comparison

Resolution of Mil Spec problems requires a broad review of 747 design against military specification of interest by Boeing and USAF. Top level policy guidelines are required to insure that this review and the decision-making associated with it concern themselves with the cost effectiveness of invoking military specification requirements on a design which is developed and proven to commercial standards and backed by over 20,000,000 flight hours of airline operation. The acceptance of contractor warranties and contractor maintenance should be considered wherever possible to avoid the added costs of Mil Spec compliance. Attachment II is taken from the Aero-Med RFP and represents an example which should be considered in future RFPs to further insure the advantages available to the government through procurement of commercial airplanes.

ATTACHMENT I

MILITARY SPECIFICATION EXAMPLES

(a) ENVIRONMENTAL QUALIFICATION COMPARISON

Typical of the environmental qualification testing differences is shown by the temperature/altitude envelope and the vibration envelope used for qualifying electronic equipment attached. The military standard is aimed at qualifying equipment for multi-use. The Boeing temperature/altitude criteria takes advantage of the fact that most equipment is located in the pressurized compartment and need not be qualified for the entire envelope for USAF Class I equipment. The Boeing vibration criteria recognizes the difference in vibration level associated with various areas of the airframe rather than qualifying all equipment to a standard level described by the military requirement. Similar differences exist in the qualification test areas of humidity, sand and dust, salt atmosphere, corrosion, fungus and electromagnetic interference.

(b) FATIGUE TEST REQUIREMENTS COMPARISON

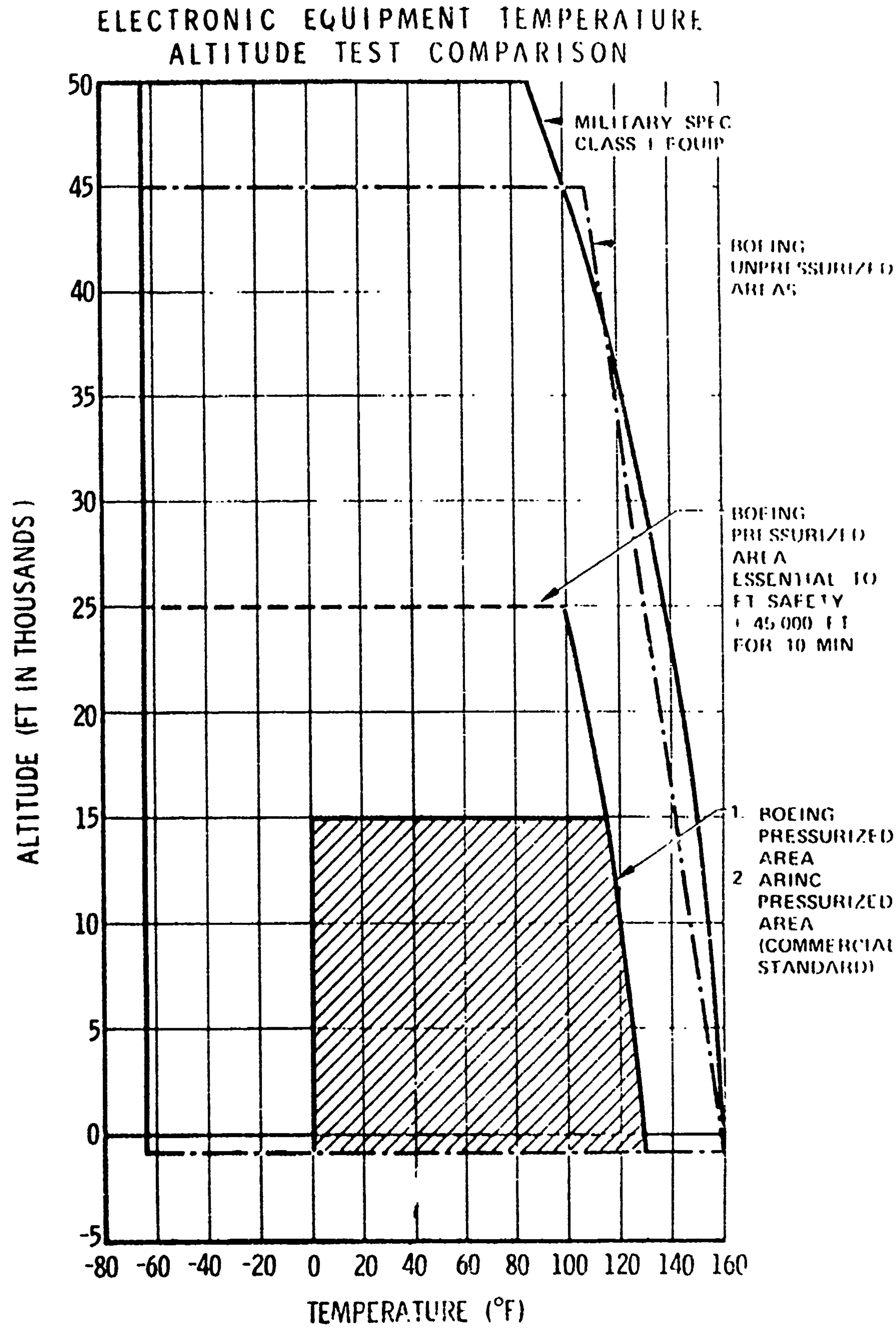
(1) Cyclic Testing

The USAF requires verification of predicted life through full scale cyclic testing of two complete airframes or sufficient structural components to ensure adequate test coverage. Boeing tests only one complete airframe, and numerous details and minor components. The extent of Boeing fatigue testing falls short of the letter of USAF requirements. The allowable deviation would be determined by discussions between Boeing and USAF.

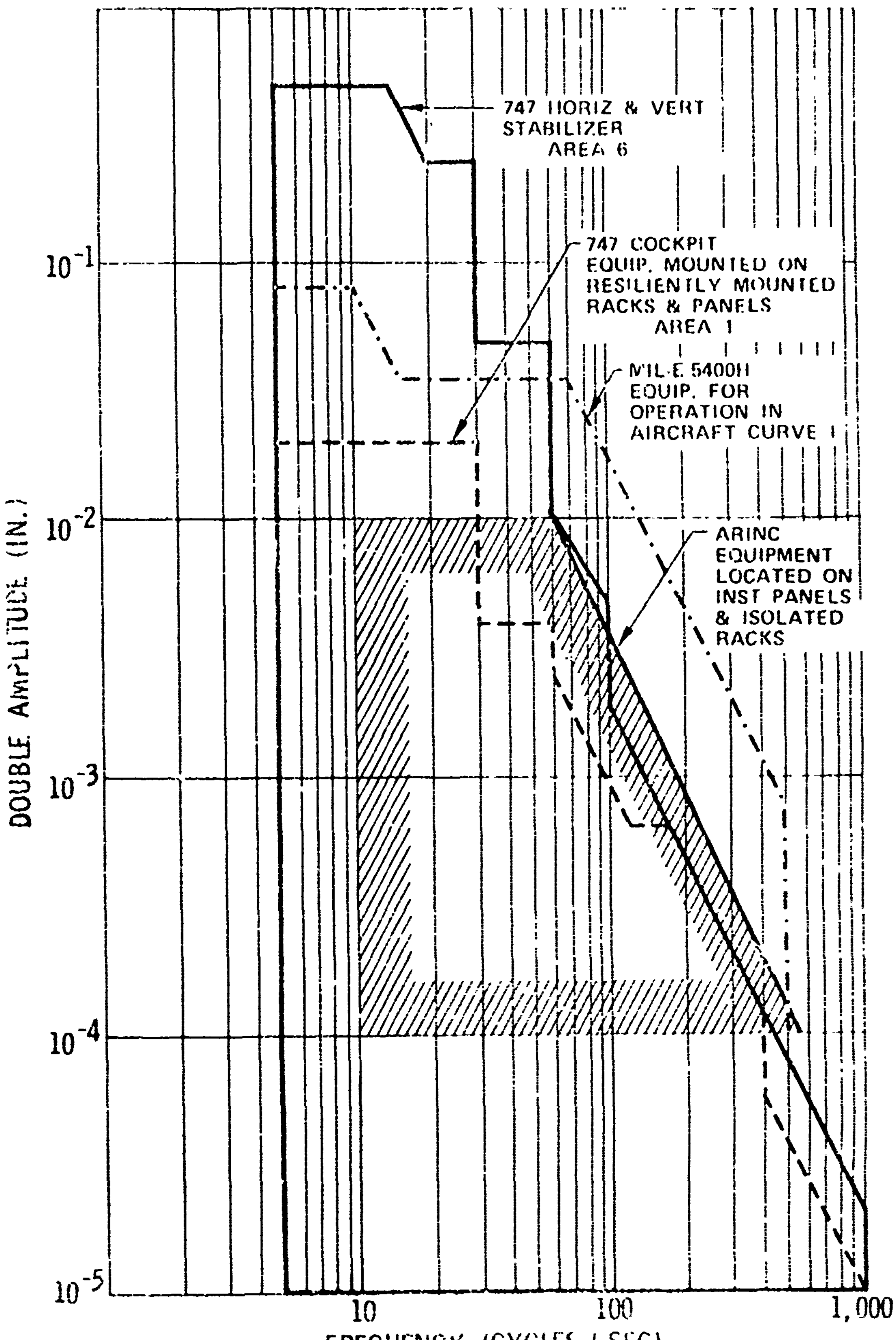
(2) Fatigue Loading

The USAF requires a higher number of high sink speed landing than does Boeing.

In general, military aircraft land at slightly higher sink speeds as witnessed by daylignt/good weather data. However, utilizing Safe-Life fatigue criteria, the 747 landing gear is designed for more than twice as many landings as that required by the military for heavy cargo type aircraft (24,600 landings versus 12,000 landings).


ELECTRONIC EQUIPMENT TEMPERATURE
ALTITUDE TEST COMPARISON
ALTITUDE (FT IN THOUSANDS)
50
45
40
35
30
25
20
15
10
5
0
-5
-80 -60 -40 -20 0 20 40 60 80 100 120 140 160
TEMPERATURE (°F)
MILITARY SPEC
CLASS I EQUIP
BOEING
UNPRESSURIZED
AREAS
BOEING
PRESSURIZED
AREA
ESSENTIAL TO
FT SAFETY
45,000 FT
FOR 10 MIN
1. BOEING
PRESSURIZED
AREA
2 ARINC
PRESSURIZED
AREA
(COMMERCIAL
STANDARD)

VIBRATION REQUIREMENTS COMPARISON



(3) Fatigue Design Philosophy

Military--Safe-Life concept for all structure.
Minimum scatter factor = 4.0

Boeing--Fail-Safe concept for all structure which has dual load paths and safe-load concept for all other primary structure. Minimum scatter factor for the 747 is 2.04 for the Fail-Safe concept and 4.08 for the Safe-Life concept.

The 747 fatigue integrity program parallels fatigue and fail-safe aspects of the Air Force Structural Integrity Program (Technical Report ASD-TR-66-57) while not required for civil aircraft certification, a dual path fail-safe - safe-life approach to structural integrity has been followed. The objectives, work phases, technical data flow between work phases and many detailed criteria (where appropriate for civil aircraft) are identical to those specified in the Air Force Structural Integrity Program. The transition from this civil airplane program to a military version would involve minimal detail criteria change and would take maximum advantage of past aircraft experience (such as 377, B-47, B-52, 707, KC-135, 727 and 737).

Since the design life of the 747 is 60,000 (30000 x 2) hours versus 120,000 (30000 x 4) hours for the USAF heavy cargo type aircraft, the 747 would most probably satisfy the military requirements without any structural modifications. The Boeing commercial primary structure life guarantee is ten years or 30,000 hours.

(c) STRUCTURAL TEST REQUIREMENTS COMPARISON

(1) Flight Vibration Tests

The USAF requires a complete vibration survey of the airframe. The extent of the survey carried out by Boeing depends on how similar a new configuration is to previous airplanes, and the extent of any problems on previous similar configurations.

An entirely new configuration (e.g., SST) would probably receive a survey that would meet USAF requirements.

(2) Ground Static Tests

The USAF requires at least one airframe to be tested to 100% of design ultimate load for all critical conditions. Failing load tests are to be conducted for each major component (wing, fuselage, and tail surface). Boeing satisfies the design ultimate load testing but does not conduct failure tests of the tail surfaces. The USAF requires that pressurized cabins be tested to 2.0 times normal operating pressure whereas Boeing limits pressure testing to approximately 1.5 times maximum operating pressure.

Boeing has a great deal of confidence in the analytical techniques used for design, and the manufacturing methods which are utilized, which are similar to past commercial configurations and proven in airline use.

A substantially new configuration in terms of shape, materials or production methods would receive closer scrutiny and possibly a more elaborate test. Multiple failures are required to subject the pressurized cabin to 1.5 times max operating pressure although the cabin is designed for 2.0 times normal operating pressure.

(3) Sonic Tests

USAF requirements include sound pressure surveys, component testing in test cells and a proof/demonstration ground test using the most severe conditions. The Boeing sonic loads analysis is based on experience with airplanes of similar construction and sample representative structural panels are tested to appropriate (high) noise levels.

Here again, a new configuration, new materials, new construction techniques or a new noise environment would require more elaborate procedures more like the military requirements.

(d) DESIGN LOADS REQUIREMENTS COMPARISON (TYPICAL)

Condition	Requirements
Roll Maneuver and Pull-out Factors	Military - 2.0 G Boeing - 1.67 G Result of difference - redesign of part of wing

Both the 2.0G and the 1.67 G factors are somewhat arbitrary; however, the Boeing design factor has proven to be satisfactory in airline use. The military requirement may have been influenced by another category of airplane and carried over into transport category for consistency.

Lateral Gust	Military vs. Boeing - 15% increase in magnitude of lateral gust for fin and aft body. Result of difference - redesign of fin and aft body.

FAA rules allow the use of a gust alleviation factor for both vertical and lateral gusts, whereas military rules allow the use of an alleviation factor for vertical gusts only. The Air Force permits the use of a random gust analysis as an alternative to the discreet analysis.

Limit Flap Speeds	Military = 1.75 V_{STALL} flaps up at max takeoff weight for all flap settings. Boeing = 1.6 V_{STALL} flaps up at max takeoff weight for takeoff flap setting. = 1.8V_{STALL} flaps in landing configuration at maximum landing weight for landing flap setting. Result of the difference - 50% increase in flap design loads.

The 747 is equipped with an automatic flap retraction system based on air speed which permits the use of the lower design loads. It is understood that this requirement is under study by the military.

Condition	Requirement
Engine Out Condition	Military = resulting load lateral gust
	Boeing = resulting load
	Result of difference - increase in fin load and extensive redesign

The combination required by the military is virtually a double failure condition and would be treated as such by Boeing. The probability of an engine failure in cruise flight is remote and the chance of ever incurring a design gust at the most critical combination of speed, altitude, gross weight, fuel and payload conditions is extremely remote.

2 pt. Braked Roll and	Military = drag reaction = .8 vert. react.
3 pt. Braked Roll	Boeing = less of .8 vert. react. or max braking capability.

Drag reactions in excess of those which can be producted by the brakes appear impractical since other design conditions (e.g., spin-up and spring-back) are considered separately as design conditions to assure adequate strength.

(3) CORROSION PROTECTION REQUIREMENTS COMPARISON (TYPICAL)

Primer

The general corrosion protection coating required per MIL-F-7179 is zinc chromate primer per MIL-P-8585. The corrosion protective coating used by Boeing is an epoxy primer per BMS 10-11. The performance requirements in BMS 10-11 meet or exceed all those in the Mil-Spec, but the BMS 10-11 materials do not conform to the specified ingredients required by the Mil-Spec. In actual comparative tests, BMS 10-11 materials have proven to be superior in chemical resistance and corrosion resistance. Compliance with the requirement to use Mil-Spec (zinc chromate) primer on all

parts would be costly and complicated in the manufacturing operation. The change would require part number changes of drawings to change finish on all parts, separate planning and purchase orders, separate processing of the parts. BMS 10-11 is resistant to Skydrol (which is fire resistant), whereas zinc chromate primer is not. Since the Air Force has standardized on zinc chromate primer, and therefore stocks this material in maintenance and overhaul depots, it is an advantage to them to use zinc chromate primer for maintenance. Zinc chromate will adhere to BMS 10-11 primer, and therefore may be used to touch up or rework parts if the Air Force so desires.

Anodizing

Aluminum specifications now require sulfuric acid anodizing per MIL-A-8625 Type II on all alloys containing over 7.5% alloying components, rather than chromic acid anodizing (Type I). These alloys primarily involved are the 7000 series. The requireme . is based on the belief that corrosion resistance requirements are not met by the chromic-anodic coatings on these alloys. Current processes used by Boeing for chromic-anodic coatings do meet and, in fact, far exceed the corrosion resistance requirements of MIL-A-8625A. The wing skins are chromic acid anodized and, in addition, are painted for corrosion protection. We do not believe that complying would produce satisfactory parts because of the known reduction in fatigue life caused by sulfuric acid anodizing.

Fastener Installation

MIL-F-7179 requires that all fasteners in exterior locations be installed with wet primer. The 747 does not require wet primer for fastener installation except in the case of dissimilar metals. The fastening of stiffeners and skins is done almost entirely by drivmatic automatic riveting devices. These are not currently designed or equipped to handle wet primer on fasteners or in holes. To comply with this requirement would require revisions in manufacturing schedules and procedures and equipment. We are continually evaluating product improvement changes in this area which would be attractive to our commercial customers as well as military.

Faying Surfaces Sealing

MIL-F-7179 requires that all non-bonded exterior faying surfaces have a sealant applied inbetween the surfaces. This is not a requirement for the 747. Most faying surfaces in the fuselage exterior are either bonded or sealed. However, wing and empennage exterior faying surfaces, including spar cavities, would require changing to comply. We are continually evaluating product improvement changes in this area which would be attractive to our commercial customers as well as military.

(f) ENGINE-POTENTIAL COMPLIANCE PROBLEM AREAS

Pratt & Whitney estimates the potential engine problem to be $30M. The areas where this money would be spent are listed below. More detailed work is required by Pratt & Whitney and the Air Force to determine what engine changes, if any, would be cost effective for the military. However, the commercial engine design and test criteria has proven to be satisfactory by over 20,000,000 flight hours of airline operation.

May require new component test facilities to accommodate additional testing.

Emergency and alternate fuels qualification.

High and low temperature starting and acceleration testing.

More severe anti-icing.

Atmospheric water ingestion.

Corrosion resistance.

More severe sand ingestion.

Infrared characteristics.

High temperature engine ratings requiring model qualification testing.

Electrical susceptibility demonstration.

Gearbox endurance demonstrations with military accessories.

Engine valve contaminated air tests.

Electrical explosion proof demonstrations.

Engine and accessories environmental demonstrations, including fungus, humidity, aging and compatibility with high and low temperature.

Impact and vibration demonstration tests.

Manual changes.

ATTACHMENT 2

EXCERPT FROM AEROMEDICAL RFP

1.1.4 Design Philosophy. The objective of the Air Force is to acquire a Federal Aviation Agency certified aircraft with only those changes absolutely necessary to make its use practical for the aeromedical evacuation mission. The aircraft shall meet civil airworthiness standards of FAR25, CAR 4b, or equivalent. This approach has been taken to preclude basic development costs and long leadtimes as well as to provide the earliest possible Operational Capability Date.

1.1.5 Responding to the Work Statement.

1.1.5.1 The requirements of the work statement are identified with FAR25, CAR 4b, Military Specification or equivalent standards. It shall be the bidder's responsibility to show how well he meets or exceeds these requirements. Special verification test efforts will be examined.

1.1.6 Detail Specification. A Detail Specification for the aircraft for use in event of contract should be prepared in conformance with attached MIL-STD-832 dated 3 June 1963 and should be included as a part of proposal data. The listing of applicable documents should include a listing of CARs, FARs and other standards, including all amendments, special regulations, special conditions, optional requirements, exemptions from compliance, which are the basis of FAA certification. The listing of applicable documents should also include a listing of company specifications and standards and those limited military requirements which are applicable. All deviations from these requirements should be included in the Appendix to the detail specification. Performance cited in the specification shall be titled "Aircraft Performance," in lieu of the three headings titled "Aircraft," "Guaranteed" and "Additional," and shall be that performance which Contractor will guarantee in event of contract.

1.2 PROCUREMENT CONCEPT. The Government plans to contract on a Multi-Year concept for an aeromedical evacuation aircraft on a FY basis with a quantity of four each specified for FY-67, and a quantity of four each specified for FY-68, with options to procure an additional quantity of 15 and 15C aircraft respectively, as set forth in the model contract.

1.2.1 Notwithstanding the requirements for equipment, performance, maintainability, reliability, etc., that may be expressed in subsequent sections of this RFP, it is the desire of the U. S. Air Force to take full advantage of the "off-the-shelf" status of your existing system. While the Technical and Operational Sections of the RFP reflect a desirable configuration of a system that would fulfill the Requirements Action Directive for an Aeromedical Evacuation Support System, it is recognized that, in some instances, full compliance may be difficult or impossible without substantial redesign. It is neither intended nor desired that the bidder enter into substantial redesign effort in order to completely comply with the requirements of this RFP. In those areas where compliance would cause development effort, extra cost and/or create more schedule risk, the bidder is encouraged to:

a. Maintain present "off-the-shelf" design and describe the degree to which this design does not comply with the requirements set forth in this RFP and/or

b. Propose an alternate approach to sensibly and economically satisfy the requirements.

APPENDIX F

747 MAINTAINABILITY PROGRAM

747 MAINTAINABILITY PROGRAM (by W. K. McKibben)

The Boeing 747 marked a new phase in the development of a commercial transport airplane. In addition to designing to meet the customary requirements of safety and performance, the airlines prescribed an unprecedented emphasis on maintainability

The three primary objectives of the 747 Maintainability Program were to minimize the length and number of airplane delays, reduce scheduled maintenance requirements, and reduce maintenance costs. With the authority of Boeing corporate policy, a six-point program plan was developed to achieve the desired objectives and implemented with the earliest design activities:

1. Education of designers and subcontractors on the principles and objectives of maintainability. Designers were supplied with a Maintainability Design Guide document, based primarily on experience. In addition, they were given educational information on airline maintenance practices and scheduling. Also provided were summary reports of historical and current maintainability data by system as well as special studies of components and systems as required. New hire designers were given special classroom training in maintainability principles.

2. Emphasis on maintenance significant items (MSI's). Maintainability engineers directed the attention of the designers to those components (MSI's) which had been costing the airlines the most in delays and maintenance dollars. Approximately 375 MSI's were identified and subjected to detailed maintainability studies. Identification was based on high initial cost, high maintenance cost, high premature removal rate, high dispatch delay rate, and high severity index. (Severity index is a rating for a component or system that accounts for the number, type, and frequency of interruptions in scheduled flight departures, as well as the length of delays, chargeable to that component or system.) Detailed maintainability studies resulted in recommendations which included time goals for component removal and replacement. From this a design maintenance plan was developed and agreed to by both the maintainability engineer and the designer.

3. Surveillance of engineering drawings and vendor proposals. Service-oriented maintainability engineers, with a broad background in maintenance practices, were placed within the design project from the beginning of the 747 design. This permitted them to support the project on specific maintainability problems, review layouts and drawings for good maintainability, conduct trade studies and participate in design reviews. Also, the tasks of the maintainability engineer included placing appropriate maintainability design requirements into specification control documents, advising Ground Support Equipment and Spares of new requirements and evaluating suppliers proposals and past maintainability performance.

4. Review of components for optimum type of maintenance control. MSI's were reviewed and information was supplied to the inter-airline working groups to aid in determining the best type of maintenance control. This will be discussed later.

5. Verification of 747 maintainability. This was accomplished by actively participating in mock-up reviews, first article inspections and the flight test program. In addition, time and task studies were performed as required.

6. Documentation. The various analyses and studies conducted throughout the 747 design and testing phases have been documented to support the airlines, to provide a record of maintainability accomplishments and to support future programs.

At Boeing, the designer has total responsibility for a successful design. Therefore, during the layout and design phases the maintainability engineer devotes the majority of his activity to points one, two and three previously mentioned, i.e., contributing to the designer's maintainability education emphasizing the maintenance significant items, and providing design surveillance.

Although airlines have differing maintenance approaches depending on variables such as route structure, schedules, utilization, and station locations, a working alliance was formed through the establishment of 747 Boeing/interairline maintainability groups.

A steering group provided general guidance for nine system-oriented working groups that included hydraulics, structures, landing gear, flight controls, power plant, pneumatics, electrical, avionics and furnishings. Membership consisted of representatives from foreign and domestic airlines, Boeing, Pratt and Whitney, and the FAA. Boeing's representatives, maintainability specialists, were assigned to supply technical data and consultation and to perform an important liaison function between the airlines and Boeing.

The ultimate objective of the inter-airline maintainability groups was to develop and submit (to the FAA Maintenance Review Board) a maintenance plan that eliminated unnecessary maintenance. A brief description of the philosophy used follows:

For systems, which includes everything except airframe structure, the 375 maintenance significant items were analyzed for the optimum type of maintenance control. This was done for each item through the use of logic diagrams. These diagrams were a useful tool that helped determine whether an item should receive some kind of scheduled periodic maintenance check or inspection based on either operating safety of the airplane or airline economics. Of the 375 items analyzed, only two were recommended for hard time overhaul and the remainder were recommended for either on-condition or condition monitoring. Condition monitoring is a statistical type control similar to the reliability control permitted by FAA Advisory Circular 120-17.

A new approach was also used for structure. Boeing identified the most stress-sensitive areas of the airplane and analyzed these items (approximately 350) for their resistance to fatigue, corrosion, stress corrosion, crack propogation as well as the degree of redundancy and fatigue test rating. From this analysis a rating number was determined which, when modified by the probability of detecting a problem externally, was used as a basis for inspection recommendations. It was recommended that internal structural items be inspected on a sampling basis with the sampling percentage based on the rating number determined by analysis. One hundred percent periodic external inspections were recommended with the frequency also based on the rating number.

One important factor that justifies low percentage sampling is the creation of a central data bank by Boeing. This data bank will summarize inspection findings submitted by the operators, thus using total fleet experience as a broad base for determining any need for modifying inspection intervals or the need for special inspections.

Through the efforts of Boeing and the maintainability steering and working groups, the resultant FAA-approved maintenance program, which sets a pattern that undoubtedly will be followed for many years, allows the airlines to benefit from the full capabilities of the 747.

In addition to the foregoing, many innovative maintainability and reliability features were incorporated which contribute to through-flight, turnaround and overnight service. No attempt will be made in this brief story to describe the designs which: improved ease of access, expanded the use of built-in test equipment or enhanced dispatch capability.

Certainly, the results of an advanced maintenance program plus the improvements made possible by the largest maintainability and reliability effort in Boeing's commercial aviation history have contributed significantly to lower maintenance costs and enhance the profit making potential of the 747.

APPENDIX G

EVALUATION OF MILITARY VS COMMERCIAL PRACTICES

GENERAL

Analyses of the answers to the questionnaires, which were sent company-wide in all phases of airplane acquisition and production, show that basically the difference between commercial and military programs is a people problem in that more people are involved from the military customer side which naturally leads to a similar number of Boeing counterparts and to more correspondence, i.e., studies, reports, meetings, telephone calls, trips, visits, documents, specifications, etc. The results of the questionnaire also indicated little difference in engineering design, testing and quality of product. This would mean the government could save time (which is money) by adjusting the degree to which people are involved on a direct interface. With the above in mind, answers to the following questions are requested.

1. What area of your responsibility is more heavily affected? (i.e., planning, managing, scheduling, accounting, testing)

   Answer - All areas are heavily affected, however, managing would be first with planning, scheduling, accounting and testing to follow, in that order. The major areas of detail involved in all of the above are the documentation and coordination necessary to meet Military Contract Requirements of ASPR, Government Source Inspection (GSI), Air Force Contract Approvals (ACO) and Coordination, Contractor Surveillance Reviews of Materiel Practices, Air Force Procurement Audits, Production Readiness Reviews (PRR), Support to Finance on DCAA Audits, etc.

   Procurement of hardware, unique to AWACS, Peace Station, T-43A, etc., must be to full government "ASPR" and other requirements, yet similar hardware is purchased to commercial requirements. The difference in the parts may be only in the "O" ring seals, as in the case of hydraulic parts.

   In a manner similar to commercial, follow-on programs have "Limited Go-ahead" with restrictions for procurement of long-lead materials. The basic difference is the flow time or timing involved with military requiring continual review and authorization of funding extensions and approvals covering short time periods, requiring almost constant control of a supplier's spending to a limit of liability curve.

2. Are there particular military specifications or standards which can be pinpointed as the causes?

   Answer - The basic Government Prime Contract is the start of restrictions, which are covered in the General Provisions and other special Terms and Conditions, which must be "Flowed-Down" to the supplier in our Request for Quotation (RFQ) and in the final Purchase Order Documents, as evidenced by Forms X20536 and X20388 for "AWACS" and Form D1-4100-4050 for "Peace Station." Also, the T-43A Program had a third set of notes, peculiar to that contract. We find that each Government Contract has different Terms and Conditions requiring the buyers to work to different sets of rules for similar parts bought from the same supplier.

2. Answer - (continued)

In addition to the above, we must procure parts similar to commercial items, but using military specifications, call-outs, etc., which may require additional inventory stocks and their control. These include all categories of parts, i.e., electrical, electronics, wire, connectors, circuit breakers, flight avionics, hydraulics, fuel systems, etc., which may be classified as standards, purchased equipment and outside production items of low or high value.

Some specific items creating high costs are:

(a) BAC D204-10285-1 use of JANTX (Hi-Rel) parts on AWACS.

(b) Boeing Document D204-14743, Nuclear Environment (AWACS). In addition, CCP 191 Proposal will require complete "EMP" test of designated unique and Commercial Common parts, which could cause redesign of many components under a Class I change designation.

(c) Numerous Military and Federal Specifications called out in our Specification Control Documents. (Example - See Boeing Document D204-13005, Electrical Power Generation System, which is similar to most "AWACS" System or Equipment Specifications.)

3. What part of these specifications and standards need to be changed and why?

Answer - This is difficult to answer in a short paragraph, as each specification would need to be evaluated to the Boeing Comparable Specifications for similar systems; however, a few examples are as follows:

(a) BAC Documents D204-10285-1, D204-10298-1 and D204-10537-1 set out AWACS Electrical and Electronics Parts Control Program and the mandatory use of JANTX (Hi-Rel) parts in the Electrical Power Generation System. The increase in cost at the supplier for six (6) basic parts, over use of commercial parts used on 707/727/737 Airplanes, for the DDT&E Contract was from $2,600 to $47,000. In addition, the supplier was required to purchase minimum mill runs of 1,000 parts, when only 100 were needed. The parts are identical to commercial, which were allowed for use in the qualification test, but could not be used on production units due to the military reliability requirements.

(b) Military specifications tend to be obsolete and are not kept up-to-date, causing problems in procuring what Engineering really desires. QPL's are not being updated to show approved sources any longer.

4. Have you data or is data available from which the saving to Boeing (and consequently, to the government) can be determined (in manhours, dollars, flight time, elapsed time, or a combination of these), if the specifications were changed?

Answer - Areas in Materiel of increased cost must be basically associated with indirect costs of manpower and materials cause by "ASPR" regulations and other special Terms and Conditions "Flow-Downs" i.e.:

4. Answer (continued)

(a) "Truth in Negotiation: (P.L. 87-653) O.P. 6-5500-402 (ASPR 3-807.3).

(b) Special Tooling - ASPR 13-704.

(c) Special Test Equipment ASPR 13-101.6.

(d) Use of Government Facilities (ASPR 13-403 and 13-502.2), O.P. 6-5500-405.

(e) Equal Opportunity Employment (Executive Order 11246) - on contracts expected to exceed $1,000,000, specific supplier approval must be obtained from the Air Force Contracting Officer (ACO) prior to award.

(f) Government Inspection Coordination (GSI).

(g) Use of Government Form DD250 on all Spares direct shipped to Air Force Depots. (No errors allowed.)

Other items include:

(h) If government would allow a greater degree of commercial practices in procurement, savings would result in many areas of overhead costs.

(i) If technical orders can be changed from the applicable military specification to ATA specification #100, it is estimated that the total data cost to AWACS would have been reduced approximately $4.4 million dollars. (Some could still be saved.)

(j) See 3(a) above for reduction in cost, if commercial electrical/electronics parts could be used in place of "JANTX." Note, this applies to new items on AWACS and is not applicable to existing common equipment used on the 707 AWACS airplane. So they are not consistent. (Many of the commercial parts have millions of hours of use in commercial aircraft; however, the military will not accept commercial experience to support military MTBF calculations and design.)

5. If assigned to supporting, or with first-hand knowledge of a derivative program, is there anything specific you are doing on your program which is better or worse than that done or being done on a similar program, i.e., T-43A vs. AWACS vs. AABNCP vs. KC-135 vs. Air Force One vs. NACA Shuttle vs. Peace Station vs. YC-14?

Answer - Many of the Materiel Buyers have worked Military Programs from B-17 to now and have seen changes, which increased costs to Boeing in the areas of overhead expense, so we can comply with contract Terms and Conditions. One recent example is the new "Cost Accounting Standards," as set forth in ASPR 7-104-83, which is not applicable to "AWACS," but is applicable to "Peace Station" and will appear in any new contracts. This requirement will cause many changes in the Boeing Accounting System and our Management Controls. The clause must be "Flowed-Down" to all suppliers and may require added effort on our part to assure suppliers are in accord and that their accounting systems are approved by the government.

GENERAL (continued)

6. Can you name specific technical requirements that need to be revised, in part or in whole, which would result in reducing contract costs without reduction in quality? This could include deletion, updating, revision or rewriting by loosening or tightening tolerances, elimination of certain tests (temperature, duration, inspection), etc.

   Answer - Reference Paragraph #3 above; however, on a new program use of vertical scale indicators in lieu of round dials would save money.

7. On the other hand, assuming the requirements are valid, are there better ways to comply? If so, what specifications and how?

   Answer - Reference Paragraph #3 above; however, others probably do exist, but would require assistance from Engineering to research.

8. Do you know of examples, trade studies, investigations, histories, presentations or reports and by whom which may be available to research for further information?

   Answer - Believe trade studies were made by Engineering on round dial indicators vs. vertical scale. This data should be available in the AWACS Engineering Project Group.

SPECIFIC

1. The initial questionnaire answers indicate the price of a part for a military program is more than a similar part for commercial programs. When buying a part from a vendor or subcontractor, what are the differences in requirements for commercial and military parts that cause the price differential?

   Answer - (a) Small quantity buys, with greater Qualification Testing, Quality Control Inspection (Boeing and Government) and Production Verification Testing Requirements.

   (b) Military Procurement carries a greater risk of cancellation.

   (c) Small quantity buys, spread over longer delivery periods, causing problems of shop load, causing high cash flow at start, with slow return of investment.

   (d) Spares potential very low and at very reduced pricing when compared to commercial programs.

   (e) Increase cost of administration; i.e., Government Audits, reports, inspection. etc.

   (f) "Hi-Rel" Parts Control Program (see General comments, Item 32).

   (g) Supplier Internal Costs:

      1. Delays caused in waiting for Government Source Inspection (GSI) to arrive and clear shipments.

1. Answer (continued)

2. Air Force Reviews of capabilities:

i Production Readiness Reviews (PRR).
ii Progress Reviews - SPDR, SCDR and Monthly Status Reviews of Progress vs. Milestones.
iii Air Force visits to suppliers, with little, if any, advance notice to buyer.
iiii Special Air Force surveillance of supplier's progress, e.g., Air Force Contract with Dynamics Research Corporation to monitor and report progress at Sundstrand and Westinghouse on the Integrated Drive Generator (IDG) Program.

3. Paperwork required in preparation of cost data, Form DD633 Cost Breakdown, etc., in accordance with "Truth in Negotiations" (Public Law 87-653). This assists Boeing and Government to negotiate lower prices by identification and exclusion of ASPR XV. Unallowable costs, with are usual costs attributed to doing business and are allowable in commercial work.

(h) Special finish standards, sealants, corrosion protections, instrument lighting (different than commercial) and other requirements peculiar to military.

2. How much difference, percentage-wise, in the price?

Answer - It is difficult to establish the difference, as many items are peculiar to the program. However, a screen of buying personnel indicates it could run:

(a) 5 to 10%, due to small quantities.

(b) 50 to 100% when "Hi-Rel" parts control is required.

(c) 15% up due to special testing and verification requirements.

3. What is your estimate on the portion of the price of a commercial part that is due to warranty program?

Answer = Most suppliers add 2 - 5% for commercial warranty; however, this is spread over a greater production quantity, with sellers knowledge that he will sell spares at a figure higher than the production unit price sold to Boeing, which is considered as a manufacturer's discount. (Common practice in commercial field, but not allowable in military.)

4. When Boeing releases a specification for bid, does competition provide a bid that is realistic or do we require a price breakdown? Have we made our own estimate of the approximate cost? Who in Boeing decides?

Answer - Corporate policy and the Materiel Buyers Guide require the use of competition on all purchases wherever possible. Military contracts, ASPR and other contract requirements, also require competition, as competition will usually provide the lowest price paid for any given article. In all cases of competition, we require cost breakdown of the supplier's proposal and the

4. Answer (continued)

buyer, with the assistance of Finance, will review the acceptable technical proposals on a cost or price analysis basis and may select other than the low bidder, due to technical reasons. This would require possible field fact-finding trips to the suppliers, to review the adequacy of their proposals by our Boeing auditors, with assistance from the local "ACO" to conduct "DCAS" reviews in areas where sellers will not reveal cost data to other than government agents (P.L. 87-653).

Materiel personnel, with Finance assistance, prepare estimates based on audited data, review it with management in Specific Procurement Board Reviews and then conduct negotiations with the supplier. (This is common practice on commercial and military procurements.)

5. With the addition specifications, do military parts have a greater acceptance rate? How much?

Answer - There is no way to compare with commercial; however, buyers feel the added specification requirements in military result in a higher rejection rate at suppliers and at Boeing during first part of a new program.

6. What reasons do suppliers give when they decline or resist bidding on parts for military programs?

Answer - (a) Do not wish to "tie up" engineering talent on such a small volume of business. They wish to use such personnel in areas of greater return, namely commercial high production programs with direct customer sale of spares, resulting in greater profit potential.

(b) Do not manufacture similar parts and, due to small quantity, do not want to "tie up" equipment.

(c) Unable to compete with supplier now producing a similar part. (Small quantity releases again.)

(d) Excessive paperwork covered by government procurements, i.e., added testing, reporting requirements, government audits in all areas, deletion of costs per ASPR XV, etc.

(e) Too much time taken for government to make decisions with the knowledge they may terminate from pressures of outside sources.

(f) Many proposals never lead to orders (exercise on ECP's, etc.).

(g) Too many schedule slides due to uncertain funding by Congress.

(h) Too many rules, regulations, procedures, Terms and Conditions, etc., which they must "flow-down" to their lower tier suppliers.

SPECIFIC (continued)

7. Are there differences in the amount and form of test and acceptance data generated by a supplier for a military product? If so, what?

Answer - Little difference in machine parts; however, in the case of purchase equipment items, namely electrical/electronics, fuels and hydraulics, we have much tighter acceptance requirements per military specifications, etc. (Reference IDG System D204-13005 and its Statement of Work, D204-10668-1, which sets out test requirements and data requirements during development and continuing through the complete production program.) (Data requirements presently keep two buyers working full time in Materiel on the AWACS Program.)

8. Is the effort (number of people) greater for the Boeing Materiel Department for a military or commercial program assuming an equal end product? If so, why?

Answer - Materiel requires a greater number of personnel to handle the military programs, namely "AWACS" and "Peace Station," due to increased requirements for purchase order documentation, procurement audits by government personnel on a scheduled quarterly basis and other audits conducted by (or requested by) the Air Force Contracting Officer (ACO), Small Business Administration, etc. None of these applies to commercial programs (i.e., any order or cumulative orders to one supplier, at one time, which exceeds $100,000 must be processed per Public Law 87-653. O.P. 6-5500-402, Special Tooling Accountability, Facilities Rental Requirements, Processing Royalties, Data Requirements, etc.).

It is well to note the Request for Quotation (RFQ) and Purchase Order Terms and Conditions within different government contracts vary, e.g., "AWACS" and "Peace Station" with enough basic differences to require special processing for each. This is not so with commercial.

9. There are indications that the government may be changing or waiving some procurement regulations in the case of derivatives. What ASPRs, etc could be changed or waived that would help contractors procure parts at a lower price without affecting quality?

Answer - I do not know of any areas where government agencies wish to waive regulations; however, on AWACS, Peace Station and the T-43A Program, they did grant specific waivers as to obtaining cost data, Form DD633's, per Public Law 87-653 on commercial common items, within specific ground rules. This also related to fabrication of new tools and/or modification of existing tooling; however, in no way have they released us from meeting the program contract Terms and Conditions. All waivers must be negotiated on specific instances relating to each Prime Contract.

The AWACS DDT&E Program Materiel Instructions, R-6550-001, is a good example of what is required on each Prime Contract. This document is about one inch thick and supplements the Boeing Buyers Guide, Operating Procedures, etc., as they relate to AWACS.

SPECIFIC (continued)

10. The nearly unanimous comment, that there is considerable lost time on military programs while waiting for a decision from the customer, would indicate this results in higher prices. What is your experience? If so, how does this increase the price?

Answer - Generally there is a lot of work that must be done during design, development etc., on a new item ahead of contract award to protect schedule. Suppliers have become cautions of entering a program that does not have full "go-ahead." They prefer to spend their development dollars on a firm requirement with good volume potential. There are many areas where lost time has caused Boeing to install parts out of sequence because the Air Force took excessive time in approving ECP and/or VECP changes. One major example was VECP 054, which changed from "VSCF" to "IDG," which was submitted to the "SPO" in September 1972, and was not approved until July 1973, requiring Boeing and suppliers to proceed in February 1973 on Boeing and supplier capital (approximately $600,000) to protect the first airplane "roll-out" schedule. This required out-of-sequence scheduling of all electronic components, generators and constant speed drives at Boeing and Rohr.

There are other instances in the area of flight avionics where we held up procurement of basic parts due to an ECP. Due to non-approval, we proceeded with the basic items risking possible termination costs if the ECP was approved. One major example here, was ECP 195, which involved Boeing and supplier coordination and expense for about eight or nine months and then was disapproved by the Air Force.

Due to this condition, we found, in general, the following areas of impact:

(a) Repeated requests to suppliers for quotations.

(b) Request to extend quotations over longer period of time.

(c) Delays to final configuration decisions, which eliminates lead time.

(d) Causes costs of overtime and use of premium transportation to meet schedules.

We are also experiencing "stretch out" of the AWACS 12 S/S Production Program, caused by delays in funding and uncertainties of whether 12 S/S or some lesser quantity will be funded. (Many suppliers have concerns here as well.) The recent schedule change for the 12 S/S Production will cause some price increases and/or use of escalation clauses heretofore not required. We also have some suppliers who have refused to accept a long lead procurement release to cover materials. They will only accept full production releases. These must be negotiated in a relatively short period of time, which is almost impossible if government field audits are required to support our cost and price analysis. This impacts schedule or forces us to accept the supplier's proposal on a firm basis to protect schedule.

SPECIFIC (continued)

11. Another comment suggested the government evaluate each company in the industry periodically to determine those who are qualified from the management and facility standpoint and thus eliminate a lot of boilerplate during proposals. Do you agree? Please comment on this approach.

    Answer - Do not agree. This would require a data bank of such large proportions, subject to imput from many areas of which we have no control or knowledg of the competence. It would only tend to increase problems, not decrease them. We would still be responsible for contract performance; therefore, we, the Prime Contractor, must continue to exercise this responsibility for control and source selection. This is not a difficult problem for Boeing, as we already know more about supplier capabilities for different products relating to our end product than anyone else does.

    Question - If this policy were established and the government set up a central procurement data bank, what kinds of information do you believe should be included?

    Answer - Many of us are against more government data banks and further, don't see how this would help us in our business. Unless commercial programs would have access to the information, we would basically handle the same as in the past. However, to be useful, the data bank would have to cover financial, past experience, facilities, both brick and mortar, and machine tools, quality performance, schedule performance, cost performance and others, broken down to commodity type items or material. This type of program on a nation wide basis would become very immense and very difficult to keep up-to-date.

The following is a summary of procedures, reporting, reviews and actions peculiar to military contracting, which must be handled by Materiel personnel over and above the normal commercial practices.

1. Truth and Negotiation Act (P.L. 87-653; O.P. 6-5500-402, Buyers Guide 3.6; ASPR 3-807.3).

2. Administrative Contracting Officer (ACO) Advance Notification/Prior Review and Consent of Purchase Orders under Government Prime Contracts. (O.P. 6-5500-500; Buyers Guide 4.6 and 9.2.)

3. Military Spares Procurement (Buyers Guide Section 2.6) and use of Government Form DD250.

4. DMS priority requalations and extension of program priority (different on each program) (Reference Buyers Guide 8.2).

5. Quality Control review of all purchase orders with subsequent review by Air Force Quality for assignment of "GSI" requirements (Buyers Guide 4.7.2 and 6.12).

6. New sources not listed in Boeing Supplier Code Document must receive the consent of the cognizant Contracting Officer (ACO) regardless of contract dollar amount (Buyers Guide Section 3.1, page 5).

SPECIFIC (continued)

7. Small Business Program (Buyers Guide 3.2 and 3.12).

8. Subcontracting with sources in areas of labor surplus (Buyers Guide 3.3, page 3).

9. Rent free use of government facilities (O.P. 6-5500-405, Buyers Guide 3.4 and 3.9).

10. Patents and Royalties (Corporate Policy 4J; ASPR 9-110; Buyers Guide 4.9).

11. Equal Employment Opportunity (EEO). (ACO clearance on all orders over $1,000,000.) Buyers Guide 4.10, ASPR 7-104-22 and 12-808.2 (a) (2), Department of the Air Force letter 4/18/74 - Procurement System Approval.

12. Foreign Procurement (Buyers Guide 5.16, page 7).

13. Progress Payments (Must meet ASPR and Prime Contract Requirements, Reference Buyers Guide 5.25).

14. Materiel Tool Control (Buyers Guide 6.2; Memo R5631-5-3414, dated 3/23/73; AWACS Buyer Instructions; O.P. R8000-028 and ASPR 13-704).

15. Value Engineering requirements per prime contract (Buyers Guide 6.3.1 and Form X20399).

16. Security and handling of classified information (both inplant and with suppliers). (Reference Boeing Security Manual and Buyers Guide 7.0.)

17. Reporting of strikes/labor disputes (Buyers Guide 7.3).

18. Digest of Military Procurement Regulations ASPR, AFPI, APP, NPD (Reference Buyers Guide 8.1).

19. Renegotiation Act of 1951 (Reference Buyers Guide 8.5).

20. Special Test Equipment (ASPR 13.101.5 and .6 and 7-104024).

21. Tax exemptions (based on prime contract).

22. AWACS DDT&E Program Materiel Instructions (list special procedures on AWACS).

23. Cost/Schedule Control System Criteria (C/SCSC).

24. Limit of Government Obligation (LOGO), per prime contract.

25. "AWACS" Supplier Data Management Plan (D2-125821-1).

26. Special Terms and Conditions applicable to military procurements:

    (a) Boeing Forms X20536 and X20388, applicable only to AWACS.
    (b) Boeing Form D1-4100-4050 applicable to Peace Station and other prime contracts.

SPECIFIC (continued)

(c) Buyers Guide, Section 9.3. Additional Terms and Conditions, special note codes which may or may not apply to each purchase in addition to standard notes used by commercial buyers.

1. Form AD 4044D-R7.
   Notes: A05, A21, A23, A24, B06, B23, B24, C01, C02, C04, C05 C08, C09, D01, E14, E17, G01, J03, J05, Q04, S05, S06, S07.

2. Special Terms and Conditions per Buyers Guide 9.3.1: A59, A60, A61, A63, A76, A78, A93, A95, A96, B64, G59, H59, J51, J52, J70, S60, U61, U62, U65.

27. Buyers must work with, and/or be aware of, specific program directives issued by BCAC Military Program Management, for each specific prime contract.

(a) "AWACS" and "Peace Station" Program Directives.

1. Tier 2 and Tier 2½ "AWACS" Milestones reporting.

2. Handling of GFP/GFAE items (Peace Station and T-43).

3. Processing and support of schedule and cost of ECP and VECP program changes (AWACS).

4. Special coordination i.e., follow-on programs etc.

(b) Work with and use "AC AWACS Engineering Instructions."

(c) Support engineering during Air Force "PDR" and "CDR" reviews.

(d) Work with and be aware of "IDWA" Statement of Work D204-10556-1 and changes directed by Program Management.

28. Support and coordinate Air Force reviews. Following reviews conducted in 1974 to date:

(a) February 26 - March 8, 1974, Air Force Procurement Audit.

(b) June 25 - 26, 1974, AWACS Program Review.

(c) August 9 - 23, 1974, Subcontractor Surveillance by Subcontract Management Division of Local AFPRO (conducted every quarter).

(d) Production Readiness Reviews (per AFSC Regulation 84-2).

1. BAC and BCAC support September 16 - 26, 1974.
2. Reviews conducted in 1974 at major subcontractors (Rohr, P&W, Sundstrand, Westinghouse).

SPECIFIC (continued)

(e) Support of special Air Force visits to suppliers for General Progress Reviews (short notice of only a few days).

(f) Support special Air Force Program Review Contracts. (Dynamics Research Corporation, Boston, Mass. has direct Air Force Contract to study progress of Integrated Drive Generators.)"

APPENDIX H

FLIGHT TEST PROGRAM COMPARISON

COMMERCIAL 737-100

VS

MILITARY 737-100

(excerpts from Flight Test Requirements Study,

Comparison of Military and

Civil Flight Test Requirements)

INTRODUCTION

The success of either a military or a civil transport airplane is due in no small measure to the Flight Test program. To develop the full potential of the machine and to uncover any design deficiencies the flight tests must be rigorous and comprehensive. Since there have been successful military and civil transport airplanes, there must be a great similarity to the basic Flight Test programs.

This document presents the results of a study conducted to determine if indeed, a similarity does exist between Flight Test programs required to certify a civil transport airplane and one required to demonstrate compliance with military specifications. The study is based upon a comparison of the civil and military flight test requirements in the following areas: Flying Qualitites, Propulsion, Structures, Systems, and Flight Manuals. The applicable portions of the Federal Aviation Regulations, Part 25, "Airworthiness Standards: Transport Category Airplanes" and The Boeing Company precertification Flight Test requirements were used as the source for the civil requirements. The military requirements were obtained from the following specifications:

MIL-F-8785	Flying Qualities of Piloted Airplanes
MIL-T-25920B	(USAF) Test Ground and Flight, Aircraft Gas Turbines Propulsion System Installation
MIL-S-5711	Structural Criteria, Piloted Airplanes, Structural Tests, Flight
MIL-A-8860	Airplane Strength and Rigidity, General Specification For
MIL-A-8866	Airplane Strength and Rigidity - Reliable Requirements, Repeated Loads, and Fatigue
MIL-A-8870	Airplane Strength and Rigidity Vibration, Flutter, and Divergence
MIL-T-5522C	Test Procedure for Aircraft Hydraulic and Pneumatic Systems, General
MIL-F-25381	Flight Testing, Electrical System, Piloted Aircraft and Guided Missile, General Requirements For
MIL-T-8207A	(USAF) Test Procedure for Aircraft Pressurized Compartment
MIL-A-9482	Anti-Icing Equipment for Aircraft, Heated Surface Type, General Specification For

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MIL-I-8700	(USAF) Installation and Test of Electronic Equipment in Aircraft, General Specification For
MIL-E-6051	Electrical-Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapons Systems, Associated Subsystems and Aircraft
MIL-M-7700A	Manuals: Flight

In order to more accurately identify the Flight Test requirements of both the FAR Part 25 and the military specifications, the study is based upon a particular airplane, namely, the Model 737-100. In addition to serving the above purpose, the designation of the 737-100 also identifies The Boeing Company document which contains precertification Flight Test requirements.

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SUMMARY

The entire testing program of the Model 737-100, including company and certification tests, was compared with the testing requirements of various MIL specifications of the Air Force. The areas covered were: Flying Qualities, Propulsion, Structures, Systems, and Flight Manuals. Only the actual tests that have been planned and documented for the Model 737 were used for comparison.

The Military and Civil test programs are very similar. In some cases the "minimum airworthiness" concept of FAR Part 25 does not require testing that is called for in the MIL specifications. However, the company engineering, precertification, and customer guarantee tests almost always fill the gap.

In a strict interpretation of the requirements some additional flight testing would be required to meet all conditions of the MIL specifications. An estimate of the additional flight hours required is as follows:

Flying Qualitites (MIL-F-8785)

Paragraph No.	Title	Additional Flight Hours
3.3.1	Elevator Fixed Static Stability	10
3.3.2.1	Elevator Free Static Stability	1
3.3.9	Control Forces In Steady Accelerated Flight	5
3.3.9	Control Forces in Dives with Trim	1
3.4.2	Spiral Stability	1
3.4.9	Adverse Yaw	1
3.4.11.1	Ten Degree Sideslip at 1.1 V_S	1
3.4.16.7	Lateral Control Effectiveness at M_D	1
3.5.7	Roll-Pitch-Yaw Coupling	2
3.7.3	Trim Change with Boost Failure	2
3.7.4	Longitudinal Control on Alternate Systems	1

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Flight Manuals (MIL-F-7700A)

Runway Surface Conditions - Three refused takeoffs

Military Electronic Installation

Additional testing would be required, not because of any descrepancy in the specification, but because Military hardware would be installed rather than the civil equipment. For the installation described in the electronic system section a total of 19 flight hours would be required if the items were tested on an individual basis. In a coordinated test program with concurrent testing this would be reduced to approximately 12 hours.

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FAA TEST PHILOSOPHY

The FAA test philosophy differs from the Air Force philosophy primarily in the way the requirements are written. The FAA does not write design specifications. They go to great lengths to avoid it. That is the main reason so many of the requirements have phrases like "operate properly for the intended function." The interpretation of most of these requirements are found in the "Advisory Circular" for the FAR Part 25 and in the "Policy" statements for the old CAR 4.b The CAR 4.b policy is still good for the Part 25 unless it has been changed by an Advisory Circular.

Because they have relatively less direct control of the design of the airplane, the FAA looks to the manufacturer to tell them what will be tested and how it will be demonstrated. The Boeing method, which is unique in the industry, is to write the "FAA Demonstration Flight Test Specification" document. This document is studied by the FAA. They then call a series of "Type Board Meetings." In these meetings the test program and airplane design is discussed in length. The FAA presents a critique of the Spec Document and proposals for changes and additional testing. The end result of these meetings is the "Type Inspection Authorization" (TIA) issued by the FAA. The TIA is the "bible" for the FAA Demonstration. The Spec Document is incorporated into, and becomes part of, the TIA.

The FAA test pilot is directly responsible for conduct of the tests. His opinion is very highly regarded. If he feels that there is some problem in the airplane, he can request changes to the testing or additional tests. Normally his requests are honored. However, if there is a serious difference of opinion, the Type Board can be convened at any time to change or add to the TIA. The TIA is not really final until the "Type Certificate" is issued. The TIA testing must be complete before the airplane is certified but a few minor exceptions may be allowed. The cleanup of these exceptions are the first order of business for the follow-on program. When changes are made to the airplane, it must be "Recertified" by demonstrating the changed item only. Any change in configuration must be certified even if it is just a new combination made up of previously certified items. (Each airline has a slightly different configuration, usually in equipment or furnishings.)

To ensure that the airplane is as the manufacturer says it is, prior to the start of FAA demonstrations, the FAA holds a "Conformity Inspection" of the test airplane. The FAA inspection checks all parts of the airplane against the blueprints. If any change is made, the manufacturer must "get conformity" on the change before it can be demonstrated.

The FAA is concerned more with the proper and safe operation of the airplane than with reliability, maintainability, or performance <u>except</u> as it effects safety (e.g., they are very concerned with the maintenance done on an airplane but not with the amount of effort required to do the maintenance). Therefore, while they tend to be specific on takeoff and landing performance, they tend not to be interested in cruise performance, specific fuel consumption, etc. These items come under a whole new heading called "Customer Guarantees" and are contained in the detail specification for each customer airplane.

DESCRIPTION OF BOEING COMMERCIAL TEST DOCUMENTATION

The basic unit of paper used for test work is the Engineering Work Authorization (EWA). The EWA has three functions: one, it authorizes the work to be done; two, it describes the test; and three, it is used as a "control" number for Planning and Cost Accounting. All test work at Boeing is done under an EWA. A typical EWA is reproduced in Appendix B.

Many EWA's are written for the tests to be conducted on any one model airplane. To assist the System Test Group in planning the conduct of these tests an EWA index document is written. This is called the "Engineering Test Plan." Appendix A contains a description and some typical pages. Because all the company pre-certification tests EWA's are indexed in it, the document is used as a "control" or reference for test planning.

The certification tests for the FAA are handled a little differently. A single EWA is written to cover all the certification tests. The Flight Test Section then writes the "FAA Demonstration Flight Test Specification." This is shown in Appendix C. This document outlines the actual test conditions in sufficient detail to accurately define the test. It is similar in scope to the One-Page Test Plans of AFR 375.

These two documents, the Engineering Test Plan and the FAA Demonstration Flight Test Specification, are the two prime reference sources for the tests to be conducted on the airplane. For a complete description of the Precertification Tests the individual EWA's would be required.

Engineering Ground Tests

For the ground tests conducted by the engineering staff, the EWA is the complete record of the test. The results, recommendations, and observations are all referenced to the EWA.

Engineering Flight Tests (FT's)

The same basic procedure is used for the FT's conducted by the Flight Operations Section. However, due to the different nature of the testing program, the Flight Operations Section imposes its own system upon the basic procedure (The EWA still remains the primary piece of paper and all others are referenced to it.) The test EWA is rewritten into a Plan of Test which is a detailed description of exactly how the test shall be conducted on the airplane. At the conclusion of each test the plan, flight log, manual notes and any other pertinent information is released to the "Plans, Logs, and Data" document. Each airplane has its own document.

When a test item is completed and the data analyzed, a Test Item Analysis Report is written. These reports are released to the "Analysis Report Document."

Appendix B contains a typical EWA, Plan, and Analysis report.

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FAA Demonstration Tests

The only major difference in procedure for Demonstrations is that the reports are signed by the FAA pilot and are released to the FAA by the Boeing Airworthiness Unit. The reports are the property of the FAA and became part of the FAA Type Inspection Report.

Flight Test Technical Manual Volume II

Volume II of the Flight Test Technical Manual contains descriptions, background, instrumentation, data requirements, and data reduction for FAA demonstration tests. It is an informational rather than a control document. A typical section from this document is in Appendix D.

Other Documentation

The above is a brief description of the test documentation only. There are many other documents that are used in conjunction with the test documents to completely document the test program. A complete description of all these is beyond the scope of this study. It is sufficient to say that very complete records are kept of all phases of flight test work.

FLIGHT HOUR COMPARISON
737-100 vs 737-100 Military

	737		737 M		
	Design Proving and Development	FAA Cert Demos	Cat I	Cat II	Cat III
Preliminary Evaluation	30		30		
Performance	84	90	90	100	
Pilot Static and OAT Sys	5	10	5	10	
Stability and Control	70	39	80	50	
Stalls	25	15	25	15	
Engine and Fuel System	20	26	25	30	
Systems					
Environmental Control	20	36	20	35	
Hydraulic	16	7	15	10	
Electric	3	4	5	5	
Pass, Cargo, Misc	3	4	5	5	
Nav and Comm	7	9	10	10	
Brakes	12	3	15	5	
Autopilot	39	10	50	30	
Flight Inst	5	5	5	5	
Structures					
Flutter	40		40		
Vibration and Fatigue	15		15		
Structural Demonstration			20		
Acoustics	8	1	10	5	
Functional and Reliability		150			
System Integration and Maintainability				190	
Accelerated Service Testing				780	
Non-Test Flying (Misc)					
Functional Chk Flt	30		30		
Sales and Publicity	50				
Ferry	20		20		
Pilot Evaluations	20		20		
	522	409	535	1385	
Boeing crew training		900			
Customer crew training and route proving		800			1885
GRAND TOTAL		2631			3805

APPENDIX J

FLIGHT TEST PROGRAM COMPARISON

COMMERCIAL 747

VS

747 MILITARY DERIVATIVE

(excerpts from

Flight Test Requirements Study -

Commercial 747 Versus Military

Derivative 747M)

INTRODUCTION

Air Force Regulation No. 80-36 states the policy and procedure for assuring that Air Force aircraft meet civil airworthiness standards set by the Federal Aviation Administration (FAA). Paragraph 4.f of AFR 80-36 states that the Air Force Systems Command is responsible to "Accept and use the results of FAA evaluations wherever possible, to reduce Air Force development and test effort or any other effort which might needlessly duplicate that already expended by FAA. Accept and use the results of FAA determination of compliance with civil air regulations."

This document records the results of a study to determine the extent to which the 747 commercial airplane qualification flight test program will satisfy the military qualification requirements for the 747M, Advanced Airborne Command Post airplane (AABNCP). The use of this information can eliminate duplication of effort on the 747M flight test program, and thereby comply with AFR 80-36.

The format of the data sheets, pages 10 through 42, is set up to follow the pertinent paragraph numbering system of the applicable military specification, which is designated at the top of the sheet. Equivalent or similar test requirements of the Federal Aviation Regulation (FAR) and Boeing engineering are noted in adjacent columns.

In regard to the FAR and Boeing engineering requirements the following items are emphasized:

1. The FAR alone would not satisfy the military specification requirements. The Federal Aviation Administration (FAA) is more concerned with proper and safe airplane operations, and less with the economic aspects of maintenance, fuel consumption, etc. However, Boeing and each customer airline are concerned in all aspects of the airplane, including economy, safety, reliability, maintainability, performance, etc. To verify that a commercial airplane meets the design requirements and is capable of meeting customer guarantees, engineering ground tests and flight tests are conducted prior to the FAA certification

flight test program.

These engineering tests ensure that the airplane configuration to be submitted for FAA certification meets the design requirements and satisfies the customer guarantees. The engineering test program for each type of commercial airplane is documented in detail.

2. The Boeing documentation for the 747 commercial airplane flight test program is in preparation, but not completed as of this date. The document descriptions on page 7 are based on actual preliminary documents and similar documents on other commercial airplane programs.

The data sheets do NOT include qualification testing of new or modified subsystems peculiar to the AABNCP missions. It is anticipated that many components used in modified subsystems will be identical to components qualified for the commercial airplanes; therefore, military qualification tests of these subsystems can be minimal. New subsystems will be tested in accordance with applicable military specifications.

REFERENCE DOCUMENTATION

1. MILITARY SPECIFICATIONS

AFR 80-36	Civil Airworthiness Standards for USAF Transport Aircraft
MIL-F-8785	Flying Qualities of Piloted Airplanes
MIL-T-25920B (USAF)	Test, Ground and Flight, Aircraft Gas Turbine Propulsion System Installation
MIL-S-5711	Structural Criteria, Piloted Airplanes, Structural Tests, Flight
MIL-A-8860	Airplane Strength and Rigidity, General Specification for
MIL-A-8866	Airplane Strength and Rigidity, Reliability Requirements, Repeated Loads, and Fatigue
MIL-A-8870	Airplane Strength and Rigidity Vibration, Flutter, and Divergence
MIL-T-5522C	Test Procedure for Aircraft Hydraulic and Pneumatic Systems, General
MIL-F-25381	Flight Testing, Electric System, Piloted Aircraft and Guided Missile, General Requirements for
MIL-T-8207A (USAF)	Test Procedure for Aircraft Pressurized Compartment
MIL-A-9482	Anti-Icing Equipment for Aircraft, Heated Surface Type, General Specification for
MIL-I-8700 (USAF)	Installation and Test of Electronic Equipment in Aircraft, General Specification for
MIL-E-6051	Electrical-Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapons Systems, Associated Subsystems and Aircraft
MIL-M-7700A	Manuals: Flight

2. FEDERAL AVIATION ADMINISTRATION

FAR Part 25	Airworthiness Standards: Transport Category Airplanes

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S U M M A R Y

This comparison study of the flight test program being planned for the commercial 747 and the flight test program defined by military specifications for cargo type aircraft (as applicable to the 747M ABNCP) indicates the following:

1. The combined civil requirements (FAR Part 25, Airworthiness Standards, Boeing engineering precertification tests, and the FAA certification flight test specification) will generally meet or exceed the equivalent military specification requirements.

2. The following tabulation lists the unmodified items common to both airplanes which will require additional testing to fully comply with military specifications.

MIL Spec	Para. No.	Title	Additional Flt. Hours
MIL-F-8785	3.3.1	Elevator-Fixed Static Stability	10
	3.3.2	Elevator-Free Static Stability	1
	3.3.9	Control Forces - Steady Accelerated Flight	5
	3.3.10	Control Forces in Sudden Pull-Ups	2
	3.3.16.1	Control Forces in Dives with Trim	1
	3.4.2	Spiral Stability	1
	3.4.9	Adverse Yaw	1
	3.4.11.1	Ten Degree Sideslip at 1.1 Stall Speed	1
	3.4.16.7	Lateral Control Effectiveness at Design Dive Speed	1
	3.5.7	Roll-Pitch-Yaw Coupling	2

MIL Spec	Para. No.	Title	Additional Flt. Hours
MIL-F-8785 (continued)	3.7.3	Trim Change with Boost Failure	2
	3.7.4	Longitudinal Control - Alternate System	1
MIL-F-25381		Essentially a new electric system for 747M	
MIL-I-8700		Essentially a new electronic system for 747M	
MIL-E-6051C		Revised electric-electronic systems will require complete EMI tests	
MIL-F-7700A		Additional taxi tests required to obtain refused takeoff data	Ground Tests
		TOTAL	28 Flt. Hours

Extensive system modification will require qualification in accordance with applicable MIL Spec. Flight hours are included in the Flight Test Program estimate.

The additional testing indicated above does not include testing of the new or modified subsystems required for the AABNCP mission. However, the additional flight test hours noted above will be combined into the total flight test program for the 747M.

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APPENDIX K

INTEGRATED DATA CONCEPT

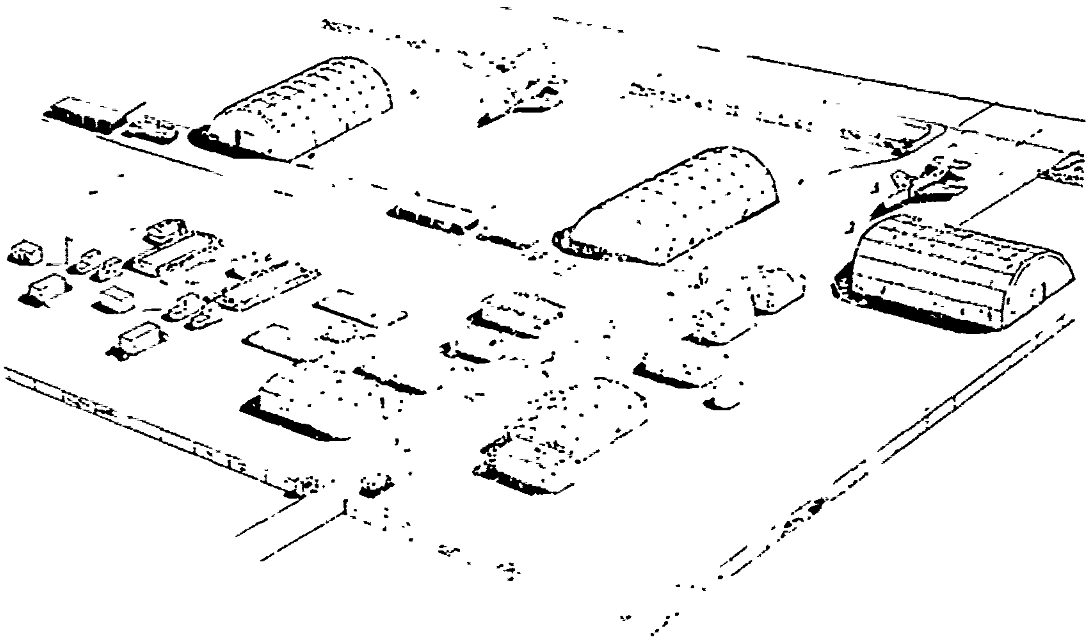
(excerpts from Exhibit 437A-72-0001A,

Bare Base System 437A)

437A-72-0001A

AIR FORCE
SYSTEMS COMMAND

BARE BASE TECHNICAL MANUAL DEVELOPMENT EXHIBIT



APRIL 1974

BARE BASE EQUIPMENT SPO (ASD/SMB)
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

3.0 REQUIREMENTS.

3.1 Technical Manual Program Objective. The objective of the Bare Base Technical Manual Program is to provide adequate data at minimum cost. Methods used to achieve this goal include:

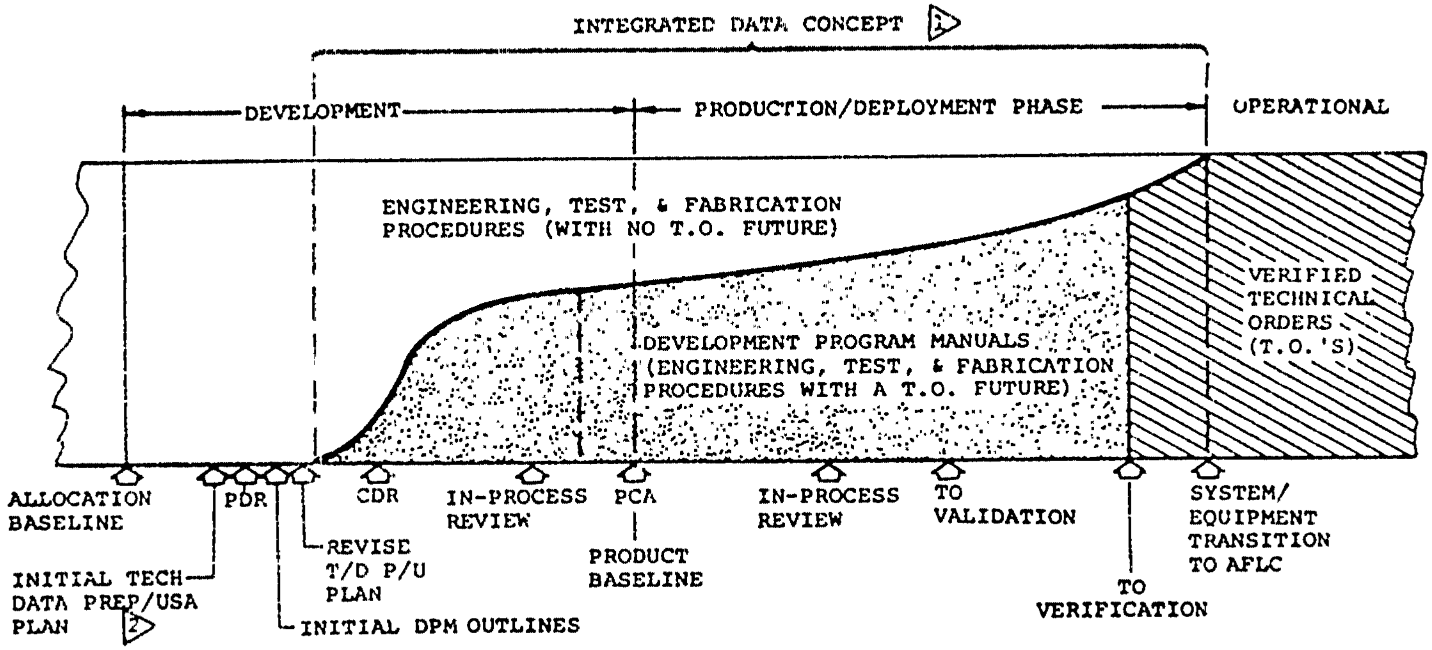
a. Use of existing technical data whenever it substantially lowers cost without seriously reducing overall data usefulness or technical accuracy.

b. Adequate, timely, and repetitive review of total data requirements to ensure data essentiality and to avoid unnecessary secondary generation of data.

3.1.1 Bare Base Integrated Data Concept. The technical manuals supporting the Bare Base systems/equipment are developed using the Bare Base Integrated Data Concept shown in Figure 3-1. This concept provides for a "single-procedure" policy in consonance with the requirements of Air Force Regulation 8-2, AFSCM 310-2, and TO 00-5-1 as cited on Figure 3-2. Maximum utilization is made of available source data with a minimum of undesirable duplication. Technical manuals are developed as an integral part of the total system requirements for hardware engineering development, production and testing. In this manner, adequate, and compatible technical manuals are provided that are reliable and cost effective!

Where commonality exists between the in-house engineering, test and other manuals, the data is prepared only once in support of all phases of the Bare Base Program. The initially required developmental and test procedural data applicable to the TO program are structured to satisfy the latter program.

Thus, under this integrated data approach, those procedures developed for use during the design, development, and test programs that are prototypic of, or identical to, production or operational program procedures are prepared so that they may be readily expanded to meet the eventual technical order requirements. Whenever feasible the format and style, as well as content, of development R&D program data are tailored to the established operational TO program requirements. Procedural support data, which are anticipated to satisfy the operational TO program, are incorporated in preliminary technical manuals or AFSCM 310-2 Developmental Program Manuals (DPMs): The technical procedural data peculiar to design, development, and test programs, with negligible application in operational TOs, are developed to provide minimum essential data consistent with adequate support for the activities involved.



1 In this concept, engineering, test, and fabrication procedures (and illustrations) that have a follow-on operational TO application are prepared and released early to support contractor activities. This early use of TO procedures is accomplished wherever contractor/Air Force procedure requirements are the same or similar. This "single-procedure" concept that is in consonance with AFR 8-2 has the following cost-saving advantages:

- Curtailment of duplication of data preparation.
- Learning curve reduction (Future T.O. program).
- Elimination of mistakes that result from secondary generation of technical data.
- Minimization of data reformating.
- Earlier and more complete data validation.
- Earlier availability of T.O. procedures for training programs and Air Force reviews.

2 This technical data in-house preparation/usage plan must be prepared and updated early in the program. This plan which should cover all technical data requirements is foundational to the ID concept.

Figure 3-1 Integrated Data Concept

- "Planning for TOs to support a system must begin during the earliest planning phases." (AFR 8-2)

- "Planning for TO development must be concurrent with the overall program planning effort." (310-2)

- "The principal reason for inadvertent data regeneration is lack of information to identify data previously prepared." (310-2)

- "Planning for TOs to support a system will begin early -- Planning will encompass all engineering and procedural support data. -- The data which will evolve into TOs will be identified and prepared in a format that will permit economical transition to TOs. To prevent undesirable duplication of effort, contractors will be encouraged to assign data specialists, supported fully by corporate management, who will provide close direction, surveillance and control over the total data development program." (00-5-1)

- "Engineering data, procedural data, or any other data that may be used for TO development, should be prepared in a manner that permits timely and economical transition to TOs." (310-2)

- "Contractors will be encouraged to use TO specification format as guide whenever feasible for preparation of engineering procedures." (310-2)

- "Previously developed procedural support data and/or DPMs should be utilized to the maximum extent possible in the development of formal TOs." (310-2)

- "Data acquired to support R&D on a new system, which is or could be applicable to the TO system, will be procured in a format that may be readily expanded for publication in accordance with a military specification. This simplifies publication efforts if TOs eventually require preparation in accordance with military specifications and formats. When TOs are required, in addition to commercial data and engineering data for support of R&D programs, these manuals are developed to be equivalent to preliminary TOs or DPMs." (AFR 8-2)

Figure 3-2 Basis for Bare Base Integrated Data Concept